Series 1960, No. 8

Issued December 1963

SOIL SURVEY
Morton County, Kansas

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service and Forest Service
in cooperation with the
KANSAS AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Morton County, Kansas, will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid foresters in managing woodland; and add to our knowledge of soil science.

Locating Soils

Use the index to map sheets at the back of this report to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map has been found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they occur on the map. The symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where the symbol belongs.

Finding Information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and Management of the Soils." In this way, they first identify the soils on their farm and then learn how these soils can be managed and what yields can be expected. The "Guide to Mapping Units, Capability Units, and Range Sites" at the back of the report will simplify use of the map and report. This guide lists each soil and land type mapped in the county, and the page where each is described. It also lists, for each soil and land type, the capability unit and range site, and the pages where these are described.

Foresters and others interested in woodland can refer to the section "Woodland Management." In that section the soils in the county are grouped according to their suitability as sites for windbreaks, and some factors affecting management are discussed.

Engineers will want to refer to the section "Engineering Properties of the Soils." Tables in that section show characteristics of the soils that affect engineering.

Scientists and others who are interested will find information about how the soils were formed and how they were classified in the section "Genesis and Morphology of the Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

Newcomers in Morton County will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Economic Geography of the County," which gives additional information about the county.

* * * * *

Fieldwork for this survey was completed in 1960. Unless otherwise indicated, all statements in the report refer to conditions in the county at that time. The soil survey of Morton County was made as part of the technical assistance furnished by the Soil Conservation Service to the Morton County Soil Conservation District.

Cover picture: Field that was wind-stripped in summer with alternate rows of sorghum, 10 rods wide, and summer fallow, 20 rods wide. The fallow strips were planted to winter wheat in fall.

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Contents

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Issued December 1963

SOIL SURVEY OF MORTON COUNTY, KANSAS

BY HAROLD P. DICKEY, W. R. SWAFFORD, Q. L. MARKLEY, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, AND FOREST SERVICE, IN COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION

MORTON COUNTY is in the southwestern part of Kansas. It is bordered on the south by Oklahoma and on the west by Colorado. The air mileage from Richfield [1] to Topeka, the State capital, and to other towns and cities is shown in figure 1. The area of the county is 725 square miles, or 464,000 acres.

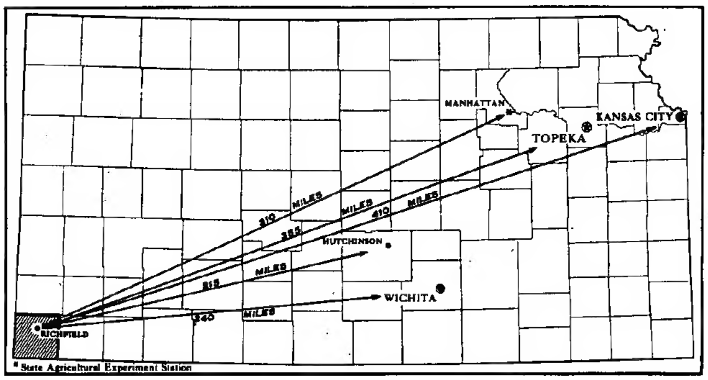

Figure 1.—**Location of Morton County in Kansas.**

Morton County is important for the production of grain sorghum and wheat. The county has a semiarid climate, and wind erosion is the chief hazard in farming. The production of natural gas and oil is the principal nonagricultural enterprise in the county.

How Soils Are Named, Mapped, and Classified

Soil scientists made this survey to learn what kinds of soils are in Morton County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the rock material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this report efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Bridgeport and Ulysses, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Many soil series contain soils that are alike except for texture of their surface layer. According to this difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Bridgeport fine sandy loam and Bridgeport loam are two soil types in the Bridgeport series. The difference in texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Ulysses silt loam, 0 to 1 percent slopes, is one of two phases of Ulysses silt loam, a soil type that ranges from nearly level to gently sloping.

After a fairly detailed guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photos for their base map because they show woodland, buildings, field borders, trees, and similar detail that greatly help in drawing boundaries accurately. The soil map in the back of this report was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly

[1] At the time this survey was made, Richfield was the county seat. In 1962 the county seat was moved to Elkhart.

equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Potter-Mansker complex. Also, in most mapping, there are areas to be shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Blown-out land or Broken land, and are called land types rather than soils.

Only part of the soil survey was done when the soil scientist had named and described the soil series and mapping units, and had shown the location of the mapping units on the soil map. The mass of detailed information he had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

To do this efficiently, he had to consult with persons in other fields of work and jointly prepare with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed primarily for those interested in producing the short-lived crops and tame pasture; range sites, for those using large tracts of native grass; tree planting sites, for those interested in establishing windbreaks; and the classifications used by engineers who build highways or structures to conserve soil and water.

General Soil Map

After studying the soils in a locality and the way they are arranged, it is possible to make a general map that shows the main patterns of soils. Such a map is the colored general soil map in the back of this report. These patterns are called soil associations. Each kind of association, as a rule, contains a few major soils and several minor soils in a pattern that is characteristic, although not strictly uniform.

The soils within any one association are likely to differ greatly among themselves in some properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general map does not show the kind of soil at any particular place, but main patterns of soils. Each pattern may contain several different kinds of soils.

Each soil association is named for the major soil series in it, but, as already noted, soils of other series may also be present. The major soil series of one association may also be present in other associations, but in a different pattern.

The general map that shows patterns of soils is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

Figure 2.—A nearly level area in the Richfield-Ulysses association.

1. *Richfield-Ulysses association: Loamy soils of uplands*

The Richfield-Ulysses association covers about 58 percent of the county. It occurs in two nearly level to gently sloping areas, mostly in the northern half of the county (fig. 2). It is composed mainly of soils with a loamy surface layer.

The principal soils in this association are the Richfield and Ulysses. The Ulysses soils make up about 52 percent of the association. They have a silt loam and loam surface layer and subsoil and are nearly level to gently sloping. Their subsoil is less clayey and blocky than that of the Richfield soils. The Richfield soils occur in nearly level areas. They make up about 38 percent of the association. They have a silt loam or loam surface layer and a silty clay loam or clay loam subsoil. The Colby, Goshen, Otero, and Manter soils make up the rest of the association.

Most of this association is used for crops and is well suited to this use. Wheat and grain sorghum are the main crops. Most of the irrigation in Morton County is done on the soils of this association.

Wind erosion is a hazard in the nearly level areas, and both wind and water erosion are hazards in the gently sloping areas. Water conservation is needed for profitable production of crops.

2. *Dalhart-Richfield association: Moderately sandy land*

This soil association covers about 17 percent of the county. It occurs south of the Cimarron River and is composed of soils with a sandy surface layer. This soil association occupies the nearly level to undulating areas that are adjacent to the Vona-Tivoli soil association.

Dalhart loamy fine sand makes up about 48 percent of this association; Richfield loamy fine sand, about 10 percent; Dalhart fine sandy loam, about 16 percent; and Richfield fine sandy loam, about 26 percent. The Dalhart soils have a sandy clay loam subsoil and are nearly level or undulating. The Richfield soils have a clay loam subsoil and are nearly level.

Most of this association is used to produce crops. Sorghum is the main crop, but wheat is grown on a small proportion of the acreage. These soils are well suited to crop production.

Figure 3.—**Soils of the Vona-Tivoli association in rolling and hilly areas.**

Wind erosion is a hazard on the soils of this association. The soils take in water readily and have a high moisture-holding capacity.

3. *Vona-Tivoli association: Rolling sandy land*

The Vona-Tivoli association covers about 18 percent of the county and occupies the rolling and hilly areas (fig. 3). Most of this association occurs south of the Cimarron River. It is composed mainly of sandy soils.

The principal soils in this association are the Vona and Tivoli. Vona loamy fine sand, the most extensive soil in this association, occupies the gently rolling areas. It has a fine sandy loam subsoil. The Tivoli soils occupy the hilly areas. They have a fine sand or loamy fine sand surface layer and a fine sand subsoil.

The soils are used mainly for pasture, which is their best use. They are not well suited to cultivated crops. Nevertheless, a small acreage is used for crops, mainly sorghum.

If they are not protected by vegetation, the soils of this association are highly susceptible to wind erosion.

4. *Otero-Lincoln association: Soils of the Cimarron River Valley and adjacent slopes*

This soil association covers about 7 percent of the county. It occupies the moderately steep slopes and the flood plains along the Cimarron River.

Potter-Mansker soils make up 17 percent of this association; Colby soils, 11 percent; Las Animas soils, 4 percent; Otero soils, 25 percent; Lincoln soils, 24 percent; Bridgeport soils, 9 percent; and the Cimarron River, 10 percent. The Colby, Mansker, Otero, and Potter soils occupy the moderately steep slopes. The Lincoln and Las Animas soils occupy the flood plains along the Cimarron River. The Bridgeport soils occupy the gently sloping areas between the moderately steep slopes and the flood plains.

The soils of this association are used mainly for pasture, which is their best use. Problems that affect their use are water and wind erosion.

Descriptions of the Soils

In this section the soil series in Morton County are described in alphabetical order. After each series, the soils of that series are described, and characteristics of these soils that differ from those described for the series are pointed out. Use and management of each soil is briefly discussed.

The acreage and proportionate extent of the soils are shown in table 1. Their location can be seen on the detailed map at the back of this report. The symbol in parentheses after the name of each soil identifies the soil on the detailed map. The capability unit and range site are given for each soil.

Many of the terms used in this section to describe soils are defined in the Glossary in the back of the report and in the Soil Survey Manual (*10*).[2]

A detailed profile description of a typical soil of each series is given in the section "Genesis and Morphology of the Soils."

TABLE 1.—*Acreage and proportionate extent of the soils*

Soil	Area	Proportionate extent
	Acres	*Percent*
Blown-out land	1,058	0.2
Bridgeport fine sandy loam, 1 to 4 percent slopes	1,274	.3
Bridgeport loam, 1 to 3 percent slopes	1,454	.3
Broken land	1,897	.4
Colby silt loam, 1 to 3 percent slopes	3,960	.8
Colby loam, 3 to 8 percent slopes	3,170	.7
Dalhart fine sandy loam, 0 to 1 percent slopes	5,066	1.1
Dalhart fine sandy loam, 1 to 3 percent slopes	8,207	1.8
Dalhart loamy fine sand, 0 to 3 percent slopes	38,058	8.2
Goshen silt loam	5,892	1.3
Las Animas soils	1,239	.3
Lincoln soils	6,579	1.4
Lofton clay loam	1,303	.3
Otero fine sandy loam, 5 to 15 percent slopes	6,865	1.5
Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded	2,548	.5
Potter-Mansker complex	4,912	1.1
Richfield fine sandy loam, 0 to 1 percent slopes	19,779	4.3
Richfield loamy fine sand, 0 to 1 percent slopes	8,022	1.7
Richfield loam, thick surface, 0 to 1 percent slopes	3,124	.7
Richfield silt loam, 0 to 1 percent slopes	99,311	21.4
Tivoli fine sand	6,711	1.4
Tivoli-Vona loamy fine sands	37,695	8.1
Ulysses silt loam, 0 to 1 percent slopes	117,985	25.4
Ulysses silt loam, 1 to 3 percent slopes	13,081	2.8
Ulysses-Colby complex, 1 to 3 percent slopes, eroded	20,634	4.4
Vona loamy fine sand	41,096	8.9
Cimarron River	3,080	.7
Total	464,000	100.0

Blown-out Land

Blown-out land (Bo).—Areas of blowouts and severely eroded land that are almost without vegetation make up this land type. They are composed of sand or loamy sand that is still being shifted by the wind. The areas occur mainly in association with the Vona and Tivoli soils on complex slopes that range from 5 to 15 percent.

Blown-out land is generally used for pasture, or it is idle. Vegetation is difficult to establish.

[2] Italic numbers in parentheses refer to Literature Cited, p. 49.

A local representative of the Soil Conservation Service should be consulted for information about revegetation of areas of this land type. (Capability unit VIIe-1, dryland; Choppy Sands range site.)

Bridgeport Series

The Bridgeport series consists of deep, light-colored, gently sloping soils that lie below the steep slopes just north of the Cimarron River. The native cover was mid and short grasses.

The surface layer is granular and brown or dark grayish brown. It is friable and absorbs moisture readily. The subsoil is a granular, light-colored, calcareous loam or clay loam that is easily penetrated by moisture and plant roots. The parent material consists of calcareous loam and clay loam sediments that came from the steeper slopes above these soils.

The Bridgeport soils have a less distinct sequence of layers and a lighter colored surface layer than the Goshen soils.

Bridgeport fine sandy loam, 1 to 4 percent slopes (Bp).—The fine sandy loam surface layer of this soil is from 6 to 14 inches thick in most places. The slopes are convex. Many intermittent drainage channels either cross this soil or end on it. Bridgeport loam and Otero fine sandy loam make up as much as 10 percent of the mapped areas of this soil.

All of this soil is used for native grass for pasture, and it is well suited to this use. (Capability unit IIIe-2, dryland; capability unit IIe-2, irrigated; Sandy range site.)

Bridgeport loam, 1 to 3 percent slopes (Br).—The loam surface layer of this soil ranges from 6 to 10 inches in thickness. The slopes are convex. Many intermittent drainage channels either cross this soil or end on it. Bridgeport fine sandy loam and Otero fine sandy loam make up as much as 10 percent of the mapped areas of this soil.

All of this soil is used to produce native grass for pasture, and it is well suited to this use. (Capability unit IIIe-1, dryland; capability unit IIe-4, irrigated; Loamy Upland range site.)

Broken Land

Broken land (Bx).—The areas of this miscellaneous land type occupy the channel and banks of the North Fork of the Cimarron River. Broken land supports a sparse stand of short and mid grasses and annual weeds. Pasture is about the only agricultural use suitable for this land type. In most areas wildlife is abundant. (Capability unit VIIw-1, dryland.)

Colby Series

Soils of the Colby series are deep, calcareous, light-colored, and loamy. They occur on gently sloping to sloping uplands along drains and on sloping areas adjoining the Cimarron River. The native cover was mid and short grasses.

The surface layer is grayish brown and is 3 to 6 inches thick. This layer is friable, takes up moisture readily, and is granular, calcareous, and highly erodible. The subsoil is pale brown, calcareous, and granular; it is easily penetrated by plant roots and moisture. The underlying material is calcareous loamy sediment deposited by wind and water.

In this county the Colby soils are associated with the Mansker, Otero, and Ulysses soils. They contain less sand throughout than the Otero, have a thinner and a lighter colored surface layer than the Ulysses, and have a deeper root zone and a darker colored subsoil than the Mansker soils.

Colby loam, 3 to 8 percent slopes (Cm).—This soil has a loam surface layer. Many intermittent drainage channels begin on the convex slopes of this soil. Runoff is medium to rapid. Otero fine sandy loam, Ulysses silt loam, and Mansker loam make up as much as 15 percent of the mapped areas of this soil.

Most of this soil is used to produce native grass for pasture (fig. 4), for which it is best suited. Both wind and water erosion are hazards to this soil, particularly water erosion. (Capability unit VIe-1, dryland; Loamy Upland range site.)

Colby silt loam, 1 to 3 percent slopes (Cb).—This soil occurs on convex single slopes. It has a silt loam surface

Figure 4.—Colby loam, 3 to 8 percent slopes.

layer. Ulysses silt loam and Mansker loam make up as much as 15 percent of the mapped areas.

About 85 percent of this soil is used to produce native grass for pasture, and the rest is used for wheat and grain sorghum. This is a marginal soil for cultivation. It is subject to wind and water erosion. (Capability unit IVe-1, dryland; Loamy Upland range site.)

Dalhart Series

The Dalhart series consists of deep, dark, well-drained sandy soils of the upland. These soils are nearly level to gently sloping and occur mostly south of the Cimarron River. The native cover was mid and tall grasses.

The brown surface layer is friable to loose and is easily tilled. It takes up moisture readily. The subsoil is brown to dark-brown, granular sandy clay loam that is easily penetrated by moisture and plant roots. The parent material consists of wind-deposited sandy sediments.

The Dalhart soils have a more sandy and less well developed subsoil than the Richfield soils. They have

more distinct layers than the Vona soils and contain more clay in the subsoil.

Dalhart fine sandy loam, 0 to 1 percent slopes (Da).—The fine sandy loam surface layer of this soil is about 6 to 12 inches thick and is moderately to highly susceptible to wind erosion. The permeability of the subsoil is moderately slow. Dalhart loamy fine sand and Richfield fine sandy loam make up as much as 15 percent of the mapped areas of this soil.

This soil is desirable for farming, but wind erosion is a hazard. Most areas are used for cultivated crops, mainly wheat and grain sorghum. (Capability unit IIIe–3, dryland; capability unit I–2, irrigated; Sandy range site.)

Dalhart fine sandy loam, 1 to 3 percent slopes (Db).—The surface layer of this soil is about 4 to 8 inches thick. The depth to calcareous material ranges from 12 to 28 inches. This soil has convex slopes that are single and complex. Dalhart loamy fine sand, Richfield fine sandy loam, and Otero fine sandy loam make up as much as 15 percent of the mapped areas of this soil.

Most of this soil is used for cultivated crops, mainly wheat and grain sorghum. Both wind and water erosion are hazards. (Capability unit IIIe–2, dryland; capability unit IIe–2, irrigated; Sandy range site.)

Dalhart loamy fine sand, 0 to 3 percent slopes (Df).—This soil has a surface layer of loamy fine sand, about 6 to 16 inches thick, that is highly susceptible to wind erosion. It has nearly level to gently sloping, complex slopes. The permeability of the subsoil is moderate to moderately slow. Vona loamy fine sand, Richfield loamy fine sand and fine sandy loam, Dalhart fine sandy loam, and Otero fine sandy loam make up as much as 15 percent of the mapped areas of this soil.

Most of this soil is used for cultivated crops, mainly grain sorghum. Wind erosion and movement of sand particles on the surface layer are the main hazards. Because of the blowing sand particles, a good stand of crops is difficult to obtain. (Capability unit IVe–6, dryland; capability unit IIIe–5, irrigated; Sands range site.)

Goshen Series

The Goshen series consists of deep, well-drained, moderately dark-colored loamy soils that occur on the flood plains of the North Fork of the Cimarron River. The native cover was mid and short grasses.

The dark grayish-brown surface layer is silt loam in most areas, but in some it is loam. This layer is friable, easily tilled, and slightly to moderately susceptible to wind erosion. The brown subsoil is a granular clay loam or loam. It is easily penetrated by plant roots and moisture. Its permeability is moderately slow. The parent material consists of calcareous loamy sediments that were deposited by water. The depth to calcareous material ranges from 10 to 18 inches.

The Goshen soils have a thicker, darker colored surface layer and a more maturely developed profile than the Bridgeport soils.

Goshen silt loam (Go).—This soil has slopes of 0 to 1 percent. Many small, intermittent drainageways end on it. As much as 10 percent of Bridgeport loam is included in areas of this soil.

This is a desirable soil for farming, and most areas are used for cultivated crops. Wheat is the main crop. This soil receives some extra moisture as runoff from nearby slopes, but fallowing is generally needed for profitable crop yields.

Wind erosion is a hazard. This soil is occasionally submerged by floodwater from the North Fork of the Cimarron River. (Capability unit IIIc–2, dryland; capability unit I–1, irrigated; Loamy Lowland range site.)

Las Animas Series

The Las Animas series consists of immature, slightly saline soils that occupy part of the flood plains of the Cimarron River. These soils are made up largely of sandy material in which occur layers of silty and clayey material. The soils are imperfectly or somewhat poorly drained. In most places the water table is within 6 feet of the surface. The native cover was salt-tolerant grasses.

In most areas the surface layer is a calcareous sandy loam, but in some areas it is loamy sand. Ordinarily, the upper 12 to 24 inches is sandy loam. This layer is friable and takes up moisture readily. The parent material consists of calcareous sandy sediment that was deposited by the Cimarron River.

The Las Animas soils contain more silt and clay in the upper 2 feet than the Lincoln soils.

Las Animas soils (Lc).—These soils have slopes of 0 to 1 percent. Lincoln soils make up as much as 5 percent of the mapped areas.

The Las Animas soils are used for native grass for pasture, and this is their best use. At times they are flooded by the Cimarron River. If they are cultivated, they are highly susceptible to wind erosion. (Capability unit VIs–2, dryland; Saline Subirrigated range site.)

Lincoln Series

The Lincoln series consists of sandy and gravelly soils on nearly level to gently undulating flood plains along the Cimarron River. The vegetation was an unstable cover of cottonwood trees, shrubs, salt-tolerant grasses, and tall native grasses.

The parent material consists of calcareous sandy and gravelly sediments that were deposited by the Cimarron River.

The Lincoln soils contain more sand in the upper 24 inches than the Las Animas soils.

Lincoln soils (Lf).—These soils have slopes of 0 to 3 percent and lie along the channel of the Cimarron River. They are unstable and may become a part of the river channel if flooded. Soil blowing also occurs on these soils. Las Animas soils make up as much as 5 percent of the mapped areas.

The Lincoln soils are not suited to cultivated crops, and all areas are used for pasture. These soils are so unstable that a stand of native grass is difficult to maintain. (Capability unit VIIw–1, dryland.)

Lofton Series

The Lofton series consists of poorly drained, dark-colored clayey soils in upland depressions. The native cover was annual plants and short grasses.

The surface layer is 4 to 10 inches of granular, dark grayish-brown clay loam. The subsoil is a very slowly

permeable, blocky light clay. Calcareous loamy sediments are more than 20 inches from the surface in most places.

Lofton soils are darker colored and more clayey in the surface layer and subsoil than the Dalhart and Richfield soils.

Lofton clay loam (Lo).—This soil occupies round or oblong, shallow depressions. It has concave or plane slopes of less than 1 percent. As much as 10 percent of the acreage of the mapped areas may have a surface layer of clay or fine sandy loam.

Most of this soil is used for cultivated crops, mainly wheat and grain sorghum. The main problem is surface ponding. In about half the years, ponded water will delay planting, drown the crop, or prevent harvesting. (Capability unit IVw-1, dryland; Loamy Upland range site.)

Mansker Series

The Mansker series consists of light-colored, moderately deep loamy soils of the upland. These are sloping soils that occupy areas just above the limestone outcrops north of the Cimarron River. In this county, they occur only in a complex with Potter soils. The native cover was short and mid grasses.

The grayish-brown surface layer generally is a calcareous, granular loam. This layer is friable and absorbs water readily. The parent material consists of highly calcareous loamy material that has weathered from the underlying limestone. The depth to limestone ranges from 15 to 30 inches.

The Mansker soils are deeper to limestone than the Potter soils.

Manter Series

The Manter series consists of dark-colored, gently sloping sandy soils of the upland. These soils occur only in a complex with Otero soils in Morton County. The native cover was mid and tall grasses.

The brown or dark-brown surface layer is moderately to highly susceptible to wind erosion. The subsoil is dark-brown, granular fine sandy loam that is friable and easily penetrated by plant roots and moisture. The parent material consists of wind-deposited sandy sediments.

The Manter soils have a darker colored and less sandy surface layer than the Vona soils, and they have a thicker, darker colored surface layer than the Otero soils.

Otero Series

The Otero series consists of light-colored, calcareous sandy soils of the upland. These deep, well-drained soils are gently and strongly sloping. The native cover was mid and tall grasses.

In most areas the surface layer is brown to dark grayish-brown fine sandy loam, 4 to 10 inches thick. It is generally calcareous and highly susceptible to wind erosion. The granular subsoil is calcareous fine sandy loam that is porous and easily penetrated by plant roots and moisture. The parent material consists of calcareous sandy sediments.

The Otero soils have a thinner and lighter colored surface layer than the Manter soils. They contain more sand throughout than the Colby soils. The Otero soils contain less sand in the surface layer than the Vona soils. They also differ in being calcareous and lighter colored throughout.

Otero fine sandy loam, 5 to 15 percent slopes (Ot).—This is a strongly sloping soil that lies along the north side of the Cimarron River. Many intermittent drainage channels and a few gravel pits occur in areas of this soil. Runoff is medium to rapid. Colby loam, Potter-Mansker complex, Bridgeport fine sandy loam, and Tivoli-Vona loamy fine sands make up as much as 15 percent of the mapped areas.

Most of this soil is used for native grass for pasture, which is the best use. The soil is susceptible to both water and wind erosion, but water erosion is the greater hazard. (Capability unit VIe-3, dryland; Sandy range site.)

Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded (Ox).—This complex consists of areas of Otero fine sandy loam and Manter fine sandy loam that were too closely associated or too intricately mixed to be mapped separately. Otero fine sandy loam makes up about 60 percent of this complex, and Manter fine sandy loam makes up about 30 percent. The two soils do not occur in a definite pattern. The complex is on ridges and along drains where slopes range from 1 to 3 percent. Colby loam and Ulysses silt loam make up as much as 15 percent of the mapped areas.

Most of the acreage of these soils is eroded. In some areas the dark-colored surface layer has been completely removed, and in other areas it is covered by wind-deposited material. Most areas, however, have not lost all of the surface soil through blowing, but some clay and most of the organic matter have been removed. At present, the surface layer is a light fine sandy loam, 4 to 12 inches thick. In most areas this light-colored layer is calcareous and is highly susceptible to wind erosion. There are numerous, small blowouts.

About 35 percent of the acreage of this complex is used for cultivated crops, mainly grain sorghum and wheat. The rest is used for native grass for pasture. Wind erosion is the major hazard. (Capability unit IVe-1, dryland; Sandy range site.)

Potter Series

The Potter series consists of very shallow soils over soft limestone. These soils occupy areas with limestone outcrops, just north of the Cimarron River in the western part of the county. In this county these soils occur only in a complex with the Mansker soils. They have a sparse cover of short and mid grasses.

The surface layer is generally loam and is less than 10 inches thick.

These soils have developed from loamy material that has weathered from the underlying limestone.

The Potter soils are shallower and occur on steeper slopes than the Mansker soils.

Potter-Mansker complex (Px).—This complex consists of soils that were too closely associated or intricately mixed to be mapped separately at the scale used. Potter loam makes up about 50 percent of the complex (fig. 5), and Mansker loam, about 25 percent. The rest consists of

Figure 5.—A view of Potter loam.

Colby loam, Otero fine sandy loam, and an unnamed soil that occurs below the limestone outcrop in a few areas. The slope generally ranges from 5 to 15 percent. Included in the areas of Potter loam are a few areas of gravelly deposits.

All of this complex is used to grow native grass for pasture, which is the best use. Productivity is low, and geologic erosion is active. Some gravelly areas of this complex are being mined. (Capability unit VIe-4, dryland; Rough Breaks-Limy Upland range site.)

Richfield Series

The Richfield series consists of deep, dark soils on nearly level upland in all parts of the county. The native cover was short, mid, and tall grasses.

The brown to dark grayish-brown surface layer ranges from loamy fine sand to silt loam. It is friable to loose and is easily tilled. The blocky clay loam subsoil is easily penetrated by plant roots and has slow to moderately slow permeability. The parent material consists of calcareous loamy sediments, mostly wind deposited. The depth to calcareous material ranges from 14 to 36 inches.

The Richfield soils have a more clayey and more compact subsoil and more distinct horizons than the Ulysses soils. They contain less sand and more clay in their subsoil than the Dalhart soils and have more distinct horizons.

Richfield fine sandy loam, 0 to 1 percent slopes (Ra).—The fine sandy loam surface layer of this soil ranges from 6 to 10 inches thick. It is moderately to highly susceptible to wind erosion. In most places the blocky subsoil is a clay loam. The depth to calcareous material ranges from 16 to 36 inches. Dalhart fine sandy loam, Dalhart loamy fine sand, and Richfield loamy fine sand make up as much as 15 percent of the mapped areas.

This soil is desirable for farming, and most areas are used for cultivated crops, mainly grain sorghum and wheat. Wind erosion is the major hazard. (Capability unit IIIe-3, dryland; capability unit I-2, irrigated; Sandy range site.)

Richfield loamy fine sand, 0 to 1 percent slopes (Rb).—The surface layer of this soil is a loamy fine sand, 6 to 16 inches thick. It is highly susceptible to wind erosion. The blocky subsoil is generally a clay loam. The depth to calcareous material ranges from 18 to 36 inches. Richfield fine sandy loam and Dalhart loamy fine sand make up 15 percent of the mapped areas of this soil.

This is a suitable soil for farming. Most areas are used for cultivated crops, mainly grain sorghum. Wind erosion is the main hazard. When the sand blows, it is difficult to get a good stand of crops. (Capability unit IVe-6, dryland; capability unit IIIe-5, irrigated; Sands range site.)

Richfield loam, thick surface, 0 to 1 percent slopes (Rk).—This soil has a loam surface layer that is generally more than 10 inches thick. This layer is moderately susceptible to wind erosion. The blocky subsoil is generally a clay loam. The depth to calcareous material ranges from 18 to 36 inches. Dalhart fine sandy loam, Richfield fine sandy loam, and Richfield silt loam make up as much as 15 percent of the mapped areas of this soil.

This is a desirable soil for farming. Most areas are used for cultivated crops, mainly wheat and grain sorghum. Moisture storage through fallowing is needed for profitable yields of wheat. Wind erosion is the major hazard. (Capability unit IIIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site.)

Richfield silt loam, 0 to 1 percent slopes (Rm).—The surface layer of this soil is silt loam, 4 to 10 inches thick. It is easily puddled and has moderate to low susceptibility to wind erosion. The blocky subsoil is generally a silty clay loam. The depth to calcareous material ranges from 14 to 24 inches. Ulysses silt loam, Richfield loam, and Richfield fine sandy loam make up as much as 10 percent of the mapped areas.

This is a suitable soil for farming. Cultivated crops, mainly wheat, are grown on most areas, but some grain sorghum is grown. Storage of moisture through fallowing is essential for profitable yields of crops. Wind erosion is the major hazard. (Capability unit IIIc-1, dryland; capability unit I-1, irrigated; Loamy Upland range site.)

Tivoli Series

The Tivoli series consists of deep, light-colored, excessively drained sandy soils of the upland. These soils occur on the dune or hilly topography of the sandy areas, mostly south of the Cimarron River. The native cover was tall grasses and sand sagebrush.

The brown surface layer is a fine sand or loamy fine sand that ranges from 3 to 8 inches in thickness. It is highly susceptible to wind erosion. The pale-brown subsoil is a loose fine sand that has rapid permeability and low moisture-holding capacity. The parent material consists of wind-deposited sand.

The Tivoli soils are more hilly and contain more sand throughout than the Vona soils.

Tivoli fine sand (Tf).—This soil has a fine sand surface layer that ranges from 3 to 6 inches in thickness. It occurs on young dunes or hilly areas (fig. 6). The slopes range from 10 to 25 percent. Vona loamy fine sand, Tivoli loamy fine sand, and Blown-out land make up as much as 10 percent of the mapped areas of this soil.

All of this soil is used to produce native grass for pasture, for which it is best suited. Wind erosion is a serious hazard. This soil should be managed so as to maintain a

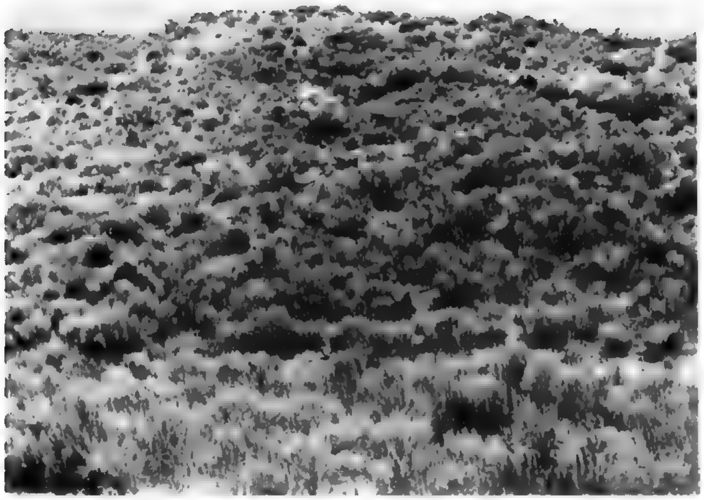

Figure 6.—**Hilly areas of Tivoli fine sand, showing sand sagebrush vegetation.**

permanent cover of vegetation. (Capability unit VIIe–1, dryland; Choppy Sands range site.)

Tivoli-Vona loamy fine sands (Tv).—This complex consists of areas of Tivoli loamy fine sand and Vona loamy fine sand that were too closely associated or too intricately mixed to be mapped separately at the scale used. Tivoli loamy fine sand makes up at least 65 percent of this complex, and Vona loamy fine sand makes up about 25 percent. Dalhart loamy fine sand and Mansker-like soils make up as much as 10 percent of the mapped areas of this complex. The soils of this complex are rolling to hilly; slopes range from 5 to 20 percent.

The surface layer of Tivoli loamy fine sand ranges from 4 to 8 inches in thickness. This soil occupies the larger and steeper hills of this complex. Vona loamy fine sand occurs in the smoother areas and in low areas between the hills.

Most of this complex is used to produce native grass for pasture, which is its best use. A small acreage is used to grow sorghum. Wind erosion is a serious hazard. A cover of native vegetation should be kept on these soils to protect them from wind erosion. (Capability unit VIe–2, dryland; Sands range site.)

Ulysses Series

The Ulysses series consists of deep, moderately dark, well-drained soils of the upland. These soils are nearly level to gently sloping and occur mostly north of the Cimarron River. They are the most extensive soils in the county. The native cover was mid and short grasses.

The silt loam or loam surface layer is dark grayish brown and ranges from 6 to 10 inches in thickness. It is friable and easily tilled. This layer puddles easily and has a moderate to low susceptibility to wind erosion.

The grayish-brown, granular subsoil is calcareous silt loam, loam, or light silty clay loam. It is friable, is easily penetrated by plant roots, and has moderately slow permeability. The parent material consists of calcareous loamy sediments, mostly wind deposited.

The Ulysses soils have a thicker and darker colored surface layer than the Colby soils. They have a less clayey and less compact subsoil than the Richfield soils.

Ulysses silt loam, 0 to 1 percent slopes (Ua).—The surface layer of this soil is silt loam, 6 to 10 inches thick. The subsoil is silt loam or light silty clay loam. The depth to calcareous material ranges from 0 to 15 inches. Richfield silt loam, Colby loam, and Colby silt loam make up as much as 15 percent of the mapped areas of this soil.

This is a suitable soil for farming, and most areas are used to grow cultivated crops, mainly wheat and grain sorghum. Storage of moisture through fallowing is needed for profitable crop yields. Wind erosion is the main hazard. (Capability unit IIIc–1, dryland; capability unit I–1, irrigated; Loamy Upland range site.)

Ulysses silt loam, 1 to 3 percent slopes (Ub).—The surface layer of this soil is silt loam, 5 to 9 inches thick. The subsoil is silt loam or loam. The depth to calcareous material ranges from 0 to 12 inches. This soil has convex slopes that range from 1 to 3 percent. Colby silt loam, Colby loam, and Otero fine sandy loam make up as much as 15 percent of the mapped areas.

Most areas are used for cultivated crops, mainly wheat and grain sorghum. Storage of moisture through fallowing is needed for profitable crop yields. Both wind and water erosion are hazards. (Capability unit IIIe–1, dryland; capability unit IIe–4, irrigated; Loamy Upland range site.)

Ulysses-Colby complex, 1 to 3 percent slopes, eroded (Ue).—This complex consists primarily of areas of Ulysses soils and Colby soils that were too closely associated or too intricately mixed to be mapped separately at the scale used. The Ulysses soils make up about 60 percent of the complex, and the Colby soils, about 30 percent. Otero fine sandy loam, Mansker loam, and Goshen silt loam make up as much as 10 percent of the mapped areas.

This complex of soils occurs on small ridges and knolls and along drains. The slopes are single and complex and range from 1 to 3 percent. Intermittent streams occur as a part of this complex.

The Colby soils are the lighter colored areas of the complex. The calcareous surface layer is generally loam, but it is silt loam in some areas. The Colby soils are in the eroded part of this complex. Erosion has caused the loss of most of their original surface layer.

The Ulysses soils are the dark-colored areas of this complex. Their surface layer ordinarily is a loam, but it is a silt loam in places.

About 75 percent of the acreage of this complex is used to grow cultivated crops, mainly wheat and sorghum. The rest is used for pasture, or it is idle. Wind and water erosion are hazards. (Capability unit IVe–2, dryland; Limy Upland range site.)

Vona Series

The Vona series consists of deep, well-drained, light-colored sandy soils that occupy rolling areas of the upland. These soils occur mostly south of the Cimarron River. The native cover was mid and tall grasses.

The brown surface layer is loamy fine sand, 6 to 20 inches thick. It takes up moisture rapidly. This layer is loose and is highly susceptible to wind erosion. The brown subsoil is very friable fine sandy loam. It is granular and is easily penetrated by plant roots and moisture. Its water-holding capacity is adequate for crop production. The parent material consists of wind-deposited sand.

The Vona soils have a less sandy subsoil than the Tivoli soils and a less clayey subsoil than the Dalhart soils.

Vona loamy fine sand (Vo).—This soil occurs on undulating areas where the range in slope is 1 to 5 percent. It absorbs and holds available for crops more of the water that falls than do most of the other soils in the county. Tivoli loamy fine sand, Dalhart loamy fine sand, Otero fine sandy loam, and Blown-out land make up as much as 15 percent of the mapped areas of this soil.

About 20 percent of the acreage of this soil is used for cultivated crops, mainly sorghum. The rest is used for native grass for pasture, and it is best suited to this use. Because it is susceptible to wind erosion, this soil is not well suited to cultivation. Wind erosion, a serious hazard, can be controlled by keeping a cover of vegetation on the surface in all seasons. (Capability unit IVe-1, dryland; capability unit IVe-7, irrigated; Sands range site.)

Effects of Erosion

This discussion deals with accelerated soil erosion in Morton County. Accelerated erosion should not be confused with the gradual, normal process of soil removal known as geologic erosion. Geologic erosion takes place under natural conditions in an undisturbed environment, but accelerated erosion is brought about by changes in the natural cover or condition of the soil caused by the activities of man.

Wind is the erosive force that does the most damage to the soils in Morton County. Wind erosion is always a hazard and may be serious if the soil lacks vegetation or surface roughness. The hazard of wind erosion depends directly on the physical characteristics and condition of the soil. Only dry soils are moved by wind. Soil blowing starts on the windward edge of an eroding area and increases progressively toward the leeward edge. Therefore, emergency tillage should begin on the windward edge of an eroding area.

Water erosion in Morton County may permanently damage the soil in sloping areas, particularly along the drainageways. On nearly level fields, water erosion normally does little permanent damage, but it is a nuisance to the farmer. A newly planted crop can be washed under by an intensive rain, and the crop will require replanting. Management practices that slow down or decrease runoff will conserve moisture and help to control water erosion.

The seriousness of erosion lies not only in the permanent damage to the soils but also in the immediate cost of repairing the damage. Replanting crops, reseeding rangeland, and using emergency tillage may remove most of the temporary effects of erosion and restore the full use of the soils, but these operations are time consuming and costly.

All of the cultivated soils in this county have had some wind erosion. In comparing cultivated soils with undisturbed soils of the same type, the cultivated soils appear to be altered only slightly. A few of the sandy soils that are being cultivated are altered somewhat by wind erosion. These sandy soils, however, have been affected more by deposits of sand and by winnowing than by removal of the surface soil.

The soils of the loamy fine sand types are highly susceptible to wind erosion, and in places the wind has piled up drifts as much as 10 feet high. Figure 7 shows some drifts around a farmstead and active blowing of the loamy fine sands. Apparently the most damaging effect of the wind on these soils is the forming of large drifts and the loss of organic matter, silt, and clay from the plow layer. Because of shifting sand, farmers may have to plant crops two or three times to establish a stand. In some areas, as a result of deposition and winnowing by the wind, some soils that originally had a fine sandy loam surface layer now have an 8- to 12-inch surface layer of loamy fine sand.

***Figure 7.*—Actively eroding loamy fine sands.**

On the nearly level and gently sloping loamy soils where active blowing occurs, small drifts will occur. The drifts will become larger and more extensive unless the soil is tilled to provide a roughened surface that resists erosion. The loamy soils do not show clearly the permanent effects of wind erosion, but much of the organic matter and some clay have been removed from their surface layer by wind.

The fine sandy loams usually have a 2- to 4-inch layer of loamy fine sand on the surface. This change in texture of the top few inches has been caused mostly by winnowing of the surface soil.

Eroded soils in the county that could be consistently mapped were placed in separate mapping units; for example, Ulysses-Colby complex, 1 to 3 percent slopes, eroded. Special symbols are used on the map to show eroded areas too small to map. The rest of the mapping units are only slightly eroded, and no symbol is used to indicate this degree of erosion.

Although the immediate effects of wind erosion are apparent, it is difficult to identify and record the lasting effects. From field observations, the effect of wind erosion on soil productivity appears to be slight.

The best method for control of wind erosion is to maintain a cover of crop residues to protect the soil from wind. Tillage helps to control erosion when the soil is bare, but it is not so effective as a cover of crop residue.

Practices needed to control erosion on a given site are discussed under the capability units in the sections "Management of Dryland" and "Management of Irrigated Soils." A representative of the Soil Conservation Service should be consulted for more specific and detailed information about the control of erosion.

Use and Management of the Soils

The use and management of the soils of Morton County are discussed in this section. The system of capability classification used by the Soil Conservation Service is ex-

plained. Dryland and irrigation management are discussed, and the soils are grouped into capability units. For each capability unit, the component soils are listed, and soil characteristics, suitable crops, and suggested cropping systems and other management are given. Productivity of the soils is discussed. The management of range and woodland are also discussed.

Capability Groups of Soils

The capability classification is a grouping of soils that shows, in a general way, how suitable they are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. There are no class V or class VIII soils in Morton County.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion; *w* means that water in or on the soil will interfere with plant growth or cultivation (in some soils the wetness can be partly corrected by artifical drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no susceptibility to erosion but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally identified by numbers assigned locally, for example, IIIc-1 or IVe-2.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

Shown in the first list that follows are the eight classes in the capability system, the subclasses, and capability units for dryland farming in this county. All the classes are listed, though some do not occur in this county. In the second list are the capability classes, subclasses, and the capability units for irrigation farming in Morton County.

CAPABILITY CLASSIFICATION FOR DRYLAND FARMING

Class I.—Soils that have few limitations that restrict their use. (None in this county.)

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices. (None in this county.)

Class III.—Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

- Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.
  - Capability unit IIIe-1.—Deep, moderately dark, gently sloping loamy soils of the upland.
  - Capability unit IIIe-2.—Deep, dark, gently sloping fine sandy loam soils of the upland.
  - Capability unit IIIe-3. -Deep, dark, nearly level fine sandy loam soils of the upland.
- Subclass IIIc.—Soils that have moderate climatic limitations.
  - Capability unit IIIc-1.—Deep, dark, nearly level loamy soils of the upland.
  - Capability unit IIIc-2.—Deep, dark-colored soils on small flood plains.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

- Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.
  - Capability unit IVe-1.—Deep, light-colored, gently sloping and undulating sandy soils of the upland.
  - Capability unit IVe-2.—Deep, moderately dark and light colored, gently sloping loamy soils of the upland.
  - Capability unit IVe-6.—Deep, dark, nearly level to gently sloping sandy soils of the upland.
- Subclass IVw.—Soils that have a very severe limitation for cultivation because of excess water.
  - Capability unit IVw-1.—Deep, dark-colored soils in shallow depressions of the upland.

Class V.—Soils not likely to erode that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover. (None in this county.)

Class VI.—Soils that have severe limitations that make them generally unsuitable for cultivation and that limit their use largely to pasture or range or wildlife food and cover.

- Subclass VIe.—Soils severely limited, chiefly by the risk of erosion if protective cover is not maintained.
  - Capability unit VIe-1.—Deep, light-colored, sloping loamy soils of the upland.
  - Capability unit VIe-2.—Deep, light-colored, rolling and hilly sandy soils of the upland.
  - Capability unit VIe-3.—Deep, light-colored, strongly sloping fine sandy loam soils of the upland.
  - Capability unit VIe-4.—Shallow and moderately deep, moderately steep and steep soils of the upland.

Subclass VIs.—Soils generally unsuitable for cultivation and limited for other uses by their moisture capacity, stones, or other features.

Capability unit VIs-2.—Moderately deep and deep, saline sandy soils with fluctuating water table on the Cimarron River flood plains.

Class VII.—Soils that have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing, woodland, or wildlife habitats.

Subclass VIIe.—Soils very severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIIe-1.—Deep, loose sandy soils of the hilly upland and blown-out areas.

Subclass VIIw.—Soils very severely limited by excess water.

Capability unit VIIw-1.—Soils on flood plains and in stream channels.

Class VIII.—Soils and landforms that have limitations that preclude their use, without major reclamation, for commercial production of plants; and restrict their use to recreation, wildlife, water supply, or esthetic purposes. (None in this county.)

Capability Classification for Irrigation Farming

Class I.—Soils that have few limitations that restrict their use.

Capability unit I-1.—Nearly level loamy soils of the upland.

Capability unit I-2.—Nearly level fine sandy loam soils of the upland.

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe.—Soils subject to moderate erosion if they are not protected.

Capability unit IIe-2.—Gently sloping fine sandy loam soils of the upland.

Capability unit IIe-4.—Gently sloping loamy soils of the upland.

Class III.—Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both.

Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.

Capability unit IIIe-5.—Nearly level to gently sloping and undulating soils, mainly loamy fine sands.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-7.—Undulating loamy fine sand soils of the upland.

Management of Dryland [3]

In Morton County, conservation of moisture is of first importance in management. Even when all moisture-conservation practices are applied, only 30 to 35 percent of the precipitation that falls during the growing period is available to the crops. The efficiency of moisture storage during the fallow period for wheat averages only about 16 percent. For example, if a total of 6 inches of precipitation occurs in the fallow period, only about 1 inch is stored in the soil.

Control of wind erosion is also important to good management. The best time to control wind erosion is "the year before it happens." It is cheaper, easier, and more practical to prevent wind erosion than to control it after it has started. Erosion can be controlled by—

1. Permanent or long-range practices, such as seeding land unsuited to cultivation to perennial grasses.
2. Seasonal practices, such as stubble mulching.
3. Emergency control practices, such as roughening the surface soil by tillage.

Generally, erosion control and water conservation are best obtained through a combination of management practices. A single practice may reduce erosion or conserve some moisture, or it may do both, but it is seldom enough for complete conservation.

The following are some management practices that maintain and improve soil productivity.

Cropping system.—A cropping system is a sequence of crops grown on a given area of soil over a period of time. It may consist of a single crop, grown year after year on the same land, or of more than one crop, grown in no regular or planned sequence. Or it may consist of a very definite, planned sequence of several crops. The cropping systems used in this county are fallow-wheat, sorghum-fallow-wheat, and continuous sorghum.

Fallowing is generally essential for economical production of wheat. The land must be managed so that soil moisture accumulates for about 11 to 14 months before the seeding of the crop.

A flexible cropping system on silt loams, loams, and fine sandy loams, used principally for wheat, is shown in table 2. This cropping system can be used as a guide in planning more stable production. (Fine sandy loams may be planted continuously to sorghum, and loamy fine sands generally are planted continuously to sorghum.)

In this flexible cropping system, it is necessary to determine the depth of moist soil and the condition of the soil cover. June 1, July 15, and September 1 have been selected as the approximate dates for determining these factors. If the depth of moist soil is less than 24 inches at planting time, crops are planted primarily for protective cover. A field has adequate cover if growing plants, residue, or both, together with cloddiness and surface roughness, will keep erosion at a minimum. Otherwise, the field has inadequate cover.

Residue management.—If tilling, planting, and harvesting are so managed that enough residue is kept on the surface of the soil at all times, the following are some of the advantages that result.

1. The most practical, effective, and economical protection against wind erosion is gained.
2. Better intake of water is maintained because the residue reduces the tendency of the soils to seal, or crust, at the surface.
3. Water erosion is reduced.
4. Crop yields are improved.

[3] By Earl Bondy, agronomist, Soil Conservation Service.

TABLE 2.—*A flexible cropping system on silt loams, loams, and fine sandy loams, where wheat is the principal crop and needed conservation practices are used* [1]

Date	Depth of moist soil	Adequate cover on field	Inadequate cover on field
	Inches		
June 1	Less than 24	Manage soil until the depth of moist soil is 24 inches; then plant sorghum or manage until July 15.	Manage soil until the depth of moist soil is 24 inches; then plant sorghum or roughen surface and manage until July 15.
	More than 24	Plant sorghum or manage for wheat	Plant sorghum, or roughen surface and manage for wheat.
July 15	Less than 30	Manage soil for wheat and expect to seed wheat primarily for a cover crop but possibly for a grain crop; be ready to plant wheat any time after Aug. 20, if the surface layer contains enough moisture.	Plant sorghum for a cover crop, or plant early maturing grain surghum.
	More than 30	Manage soil for wheat, expecting a grain crop	Manage soil for wheat and expect to seed wheat primarily for a cover crop but possibly for a grain crop.
Sept. 1	Less than 36	Plant wheat, expecting a grain crop (the soil should be moist to a depth of at least 24 inches at seeding time); if there is not enough moisture in the surface soil for seeding of wheat, manage for crop production in the next year.	Plant wheat for a cover crop but possibly for a grain crop; if there is not enough moisture for seeding of wheat, roughen surface and manage for sorghum or wheat to be grown in the next year.
	More than 36	Plant wheat, expecting a grain crop; if moisture conditions in the surface soil are unfavorable for seeding of wheat, manage for crop production in the next year.	Plant wheat for a cover crop but possibly for a grain crop; if moisture in the surface soil is unfavorable for seeding wheat, roughen surface and manage for sorghum to be grown in the next year.

[1] Prepared by FRED MEYER, JR., work unit conservationist, Syracuse, Kans.

Residue management should be practiced on all cultivated soils (fig. 8). The amount of residue needed to protect the soil varies according to the kind of residue and the texture of the surface soil. The goal is to get enough residue to provide protection without seriously interfering with seeding of crops or control of weeds. A local representative of the Soil Conservation Service should be consulted for information on the minimum amount of residue needed to protect each of the soils in Morton County.

Residue should not be burned. Also, grazing of residue is not advisable, particularly on loamy fine sands. If residue is grazed, an adequate amount of residue should be maintained on the field to control wind erosion.

Figure 8.—**Wheat has been planted in stubble on this field of Richfield silt loam, 0 to 1 percent slopes. About 1,000 pounds of residue per acre are still on the surface.**

Tillage implements best suited for residue management of wheat stubble are those that undercut the stubble and leave most of it on the surface. After four operations, these implements usually leave more than 40 percent of the residue on the surface. The first tillage in the spring should be done after weeds start to grow. The next will be needed after there is another growth of weeds. A rodweeder is often best for the last tillage before the drilling of wheat. It will kill small weeds and firm the seedbed.

If grain sorghum is to be grown, undercutting implements are suitable for the first tillage in the spring. A lister-type implement equipped with a planter is generally used to plant grain sorghum, particularly if sorghum is grown continuously. On sandy soils the preparation of the seedbed should be delayed until late in spring to keep as much sorghum residue on the surface as possible.

There is no substitute for a good cover of growing crops or crop residue. The soils need a cover throughout the year.

Tillage.—The purposes of tillage are to prepare the seedbed, to control weeds, and to manage crop residue. All tillage operations should help produce and maintain good tilth, or physical condition, of the surface soil. In Morton County, tillage is the principal means by which a farmer carries out his soil management program.

The soil should be tilled only when it is necessary to break up a surface crust, to control weeds, or to prepare a seedbed. This will be referred to as *minimum tillage*. Too much tillage breaks down the granulation of the soil, destroys the crop residue, and leaves the soil bare.

One or more tillage operations to roughen the surface of the soil will make a bare soil less susceptible to blowing.

***Figure 9.*—Water retained by terraces on a nearly level field.**

This practice should be done before or just after the soils begin to blow. Fields should be tilled across the direction of the wind that causes erosion. The tillage should be started on the windward edge of an area subject to blowing.

Tillage that roughens the surface is the most effective on soils having a loam or a finer textured surface soil. On soils with a loamy fine sand surface soil, emergency tillage is ineffective or, at best, effective only for a short time.

Terracing.—This practice consists of the construction of ridges across the slope to intercept runoff. In Morton County, terraces are built without grade. They are sometimes called level terraces. On sloping fields, terraces help to control erosion, as well as to conserve moisture. On nearly level fields, terraces are used mainly to conserve moisture (fig. 9).

Contour farming and other conservation practices should be used with terracing. Each row that is planted on the contour between terraces acts as a miniature terrace; it holds back some water and lets it soak into the soil. When terracing and contouring are used together, yields are increased and soil losses are decreased.

The horizontal distance needed between terraces depends largely on the slope. Since much of the rainfall is intensive, the terrace system protects other conservation practices.

Contour farming.—In contour farming the soil is tilled parallel to terraces or contour guidelines. As a result, furrows, ridges, and wheel tracks are nearly level across the slope. The furrows and ridges hold much of the water where it falls and thus decrease runoff and erosion. Yields of crops increase because more water is absorbed by the soil and made available to crops.

Contour farming is most effective when used with other conservation practices, such as residue management, terracing, and contour stripcropping.

Stripcropping.—This is a system of growing suitable crops in narrow strips on the same field. Strips of erosion-resistant growing crops or of their residue are alternated with strips of other crops or with fallowed strips. Good stands of wheat and sorghum and their thick, heavy stubble are considered erosion resistant. Stripcropping helps control wind erosion by shortening the distance that loose soil can move. It provides a barrier of growing crops to reduce water erosion.

Two types of stripcropping are (1) contour stripcropping and (2) wind stripcropping. Contour stripcropping is used on sloping fields to help control both wind and water erosion. The strips are arranged on the contour; terraces or contour guidelines are used to establish the pattern.

Wind stripcropping is used on nearly level fields where water erosion is not a problem and on some sloping fields where the slopes are so complex that farming on the contour is not practical. The strips are uniform in width, are straight, and usually run from east to west. The width of the strip necessary to control soil blowing varies according to the kind of soil. On silt loams, loams, and clay loams, the maximum width of each strip should be not more than 20 rods. On sandy loams, the maximum width should be not more than 10 rods.

Stripcropping will reduce soil blowing but does not completely control it when used alone. It is most effective when used with other needed conservation practices.

Management by capability units (dryland)

In this section the soils of Morton County are grouped in capability units for dryland farming. The significant features of the soils in each capability unit, together with their hazards and limitations, are described. Suggestions for use and management of the soils of each unit are also given.

CAPABILITY UNIT IIIe-1 (DRYLAND)

This unit is made up of deep, moderately dark, gently sloping loamy soils of the upland. The surface soil is loam or silt loam; the subsoil is loam, silt loam, or clay loam. The soils in this unit are—

Bridgeport loam, 1 to 3 percent slopes (Br).
Ulysses silt loam, 1 to 3 percent slopes (Ub).

These soils have a high moisture-holding capacity and are easily penetrated by plant roots. Conservation of moisture and control of wind and water erosion are problems.

Wheat and grain sorghum are suitable crops. The cropping system used is fallow-wheat or sorghum-fallow-wheat.

Storage of moisture through fallowing is essential for profitable crop yields. Residue management and minimum tillage will help to control wind and water erosion and to conserve moisture. Contour stripcropping also may be used. Terracing and contour farming are other practices needed. The soils in this unit are in the Loamy Upland range site.

CAPABILITY UNIT IIIe-2 (DRYLAND)

This unit is made up of deep, dark, gently sloping fine sandy loam soils of the upland. They have a fine sandy loam surface soil and a loam to sandy clay loam subsoil. The soils in this unit are—

Bridgeport fine sandy loam, 1 to 4 percent slopes (Bp).
Dalhart fine sandy loam, 1 to 3 percent slopes (Db).

These soils have a moderate to high moisture-holding capacity and are easily penetrated by plant roots. Conservation of moisture and control of wind and water erosion are problems.

Grain sorghum and wheat are suitable crops. The cropping system used is fallow-wheat, sorghum-fallow-wheat, or continuous sorghum.

Storage of moisture through fallowing is generally essential for profitable yields of wheat. Residue management and minimum tillage are needed to control water and wind erosion, and they help conserve moisture. Contour farming and stripcropping also may be used. Crop residue should not be grazed. After a new crop is planted, at least 1,250 pounds of wheat residue or 1,750 pounds of sorghum residue are needed to prevent wind erosion.

Terraces may be constructed to control water erosion and to help conserve moisture. The use of nitrogen fertilizer is profitable in years when rainfall is above normal, or when there is a reserve of moisture at the beginning of the growing season. The soils in this unit are in the Sandy range site.

CAPABILITY UNIT IIIe-3 (DRYLAND)

This unit consists of deep, dark, nearly level fine sandy loam soils of the upland. These soils have a fine sandy loam surface layer and a sandy clay loam to clay loam subsoil. The soils in this unit are—

Dalhart fine sandy loam, 0 to 1 percent slopes (Da).
Richfield fine sandy loam, 0 to 1 percent slopes (Ra).

These soils have a high moisture-holding capacity and are easily penetrated by plant roots. Conservation of moisture and control of wind erosion are problems.

Wheat and grain sorghum are suitable crops. The cropping system used is wheat-fallow or sorghum-fallow-wheat. Grain sorghum is grown several years in succession when rainfall is above normal.

Storage of moisture through fallowing is generally needed for profitable crop yields. Residue management and minimum tillage are needed to control wind erosion and to help conserve moisture. Contour farming and stripcropping also may be used. Nitrogen fertilizer can be used profitably on sorghum in years of above-average rainfall, or when there is a reserve of moisture at the beginning of the growing season. For the control of wind erosion, these soils need about 1,250 to 1,750 pounds of residue on the surface after a new crop has been seeded. The soils in this unit are in the Sandy range site.

CAPABILITY UNIT IIIc-1 (DRYLAND)

This unit consists of deep, dark, nearly level loamy soils of the upland. The texture of the surface layer is silt loam or loam, and the subsoil is silt loam or clay loam. The soils in this unit are—

Richfield loam, thick surface, 0 to 1 percent slopes (Rk).
Richfield silt loam, 0 to 1 percent slopes (Rm).
Ulysses silt loam, 0 to 1 percent slopes (Ua).

These soils have a high moisture-holding capacity and are easily penetrated by plant roots. Conservation of moisture and control of wind erosion are problems.

Wheat and grain sorghum are suitable crops. The cropping system used is fallow-wheat or sorghum-fallow-wheat.

Storage of moisture through fallowing is essential for profitable crop yields. Residue management and minimum tillage are needed to control wind erosion and to help conserve moisture. Contour farming and stripcropping also may be used. Terraces will help to conserve moisture. The soils of this unit are in the Loamy Upland range site.

CAPABILITY UNIT IIIc-2 (DRYLAND)

Only one soil is in this capability unit. It is a deep, dark-colored soil that occurs on small flood plains along the North Fork of the Cimarron River. It has a silt loam surface layer and a loam or clay loam subsoil. The soil in this unit is—

Goshen silt loam (Go).

This soil has a high moisture-holding capacity and is easily penetrated by plant roots. At times, it receives some extra moisture as runoff from surrounding areas. Conservation of moisture and control of wind erosion are problems.

Wheat and grain sorghum are suitable crops. A suitable cropping system is fallow-wheat or sorghum-fallow-wheat.

Storage of moisture through fallowing is essential for profitable crop yields. Residue management and minimum tillage are needed to control wind erosion and to help conserve moisture. The soil in this unit is in the Loamy Lowland range site.

CAPABILITY UNIT IVe-1 (DRYLAND)

This unit consists of deep, light-colored, gently sloping and undulating sandy soils of the upland. These soils have a loamy fine sand or fine sandy loam surface layer and a fine sandy loam subsoil. The soils in this unit are—

Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded (Ox).
Vona loamy fine sand (Vo).

These soils have a moderate to low moisture-holding capacity. Wind erosion is a serious problem; therefore, the soils are poorly suited to crops.

Sorghum can be grown for grain or forage or to provide residue for erosion control. The cropping system is generally continuous sorghum.

Residue management and minimum tillage are needed to control wind erosion. Crop residue should not be grazed; it should be left on the surface for protection against wind erosion. Many areas should be seeded to native grasses and used for pasture. Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded, is in the Sandy range site, and Vona loamy fine sand is in the Sands range site.

CAPABILITY UNIT IVe-2 (DRYLAND)

This unit is made up of deep, moderately dark and light colored, gently sloping soils of the upland. These soils have a silt loam or loam surface soil and subsoil. The soils in this unit are—

Colby silt loam, 1 to 3 percent slopes (Cb).
Ulysses-Colby complex, 1 to 3 percent slopes, eroded (Ue).

These soils have a high moisture-holding capacity. Conservation of moisture and control of wind and water erosion are problems. The soils are not well suited to cultivated crops, but wheat and grain sorghum are grown. The cropping sequence in use is wheat-fallow or sorghum-fallow-wheat.

Storage of moisture through fallowing is essential for profitable crop yields. Residue management and minimum tillage are needed to help control wind and water erosion and to conserve moisture. Terracing, contour farming, and stripcropping are also needed. Some areas should be seeded to native grasses and used for pasture. Colby silt loam, 1 to 3 percent slopes, is in the Loamy Upland range

site, and Ulysses-Colby complex, 1 to 3 percent slopes, eroded, is in the Limy Upland range site.

CAPABILITY UNIT IVe-6 (DRYLAND)

This unit consists of deep, dark, nearly level to gently sloping sandy soils of the upland. These soils have a loamy fine sand surface layer and a sandy clay loam to clay loam subsoil. The soils in this unit are—

Dalhart loamy fine sand, 0 to 3 percent slopes (Df).
Richfield loamy fine sand, 0 to 1 percent slopes (Rb).

These soils have a high moisture-holding capacity and are easily penetrated by plant roots. Wind erosion is the major problem.

Sorghum is a suitable crop, and it is generally grown year after year.

Residue management and minimum tillage are needed to control wind erosion. Crop residue should not be grazed, it should be left on the surface to protect the soils from blowing. The use of nitrogen fertilizer is generally profitable. The soils in this unit are in the Sands range site.

CAPABILITY UNIT IVw-1 (DRYLAND)

This unit consists of a deep, dark-colored soil that occupies shallow depressions of the upland. After rainstorms, water is ponded on this soil for several days. The soil in this unit is—

Lofton clay loam (Lo).

This soil has a high moisture-holding capacity and very slow permeability. Wetness caused by ponding is the major problem.

This soil is usually managed like the surrounding soils. Terraces may be used on surrounding soils to keep excess water out of the depressions. Residue management and minimum tillage should be used to control wind erosion. Lofton clay loam is in the Loamy Upland range site.

CAPABILITY UNIT VIe-1 (DRYLAND)

Only one soil is in this capability unit. It is a deep, light-colored, sloping soil of the upland. The surface layer and subsoil are loam. The soil in this unit is—

Colby loam, 3 to 8 percent slopes (Cm).

This soil has a high moisture-holding capacity. It is generally calcareous at the surface. Both wind and water erosion are hazards.

Because of the hazard of erosion, this soil is best suited to native grass pasture. Grassland management practices needed are proper range use, deferred grazing, and rotation-deferred grazing. This soil is in the Loamy Upland range site.

CAPABILITY UNIT VIe-2 (DRYLAND)

This unit consists of deep, light-colored, rolling and hilly sandy soils. These soils have a loamy fine sand surface layer and a fine sand to fine sandy loam subsoil. The following complex of soils is in this unit—

Tivoli-Vona loamy fine sands (Tv).

These soils have a low moisture-holding capacity. Because wind erosion is a serious hazard, a cover of native vegetation should be maintained to protect the soils from blowing.

These soils are best suited to native grass pasture. Grassland management practices needed are proper range use, deferred grazing, rotation-deferred grazing, and range seeding where needed. The soils of this complex are in the Sands range site.

CAPABILITY UNIT VIe-3 (DRYLAND)

This unit consists of only one soil. It is a deep, light-colored, strongly sloping soil of the upland. It has a fine sandy loam surface layer and subsoil. The soil in this unit is—

Otero fine sandy loam, 5 to 15 percent slopes (Ot).

This soil has a moderate moisture-holding capacity and is generally calcareous at the surface. Both wind and water erosion are hazards.

Because of the risk of erosion, this soil is best suited to native grass pasture. The areas that are now cultivated should be seeded to suitable native grasses and used for pasture. Grassland management practices needed are proper range use, deferred grazing, rotation-deferred grazing, and range seeding where needed. This soil is in the Sandy range site.

CAPABILITY UNIT VIe-4 (DRYLAND)

This unit consists of shallow and moderately deep, moderately steep and steep soils of the upland. These soils have a loam surface layer. The following complex of soils is in this unit—

Potter-Mansker complex (Px).

These soils have a low to moderate water-holding capacity. They are best suited to native grass pasture. Water erosion is the main hazard. The steep slopes in this unit have a sparse cover of vegetation. Grassland management practices needed are proper range use, deferred grazing, and rotation-deferred grazing.

The soils of this complex are in the Rough Breaks-Limy Upland range site. More information on management of these soils for range is in the section "Range Management."

CAPABILITY UNIT VIs-2 (DRYLAND)

This unit consists of moderately deep and deep, saline sandy soils that occupy a part of the Cimarron River flood plains. The soils in this unit are—

Las Animas soils (Lc).

These soils are occasionally flooded. If used for crops, they are highly susceptible to wind erosion. They have a fluctuating water table that is generally within 6 feet of the surface.

Las Animas soils are well suited to native grass pasture or meadow. Grassland management practices needed are proper range use, deferred grazing, and rotation-deferred grazing. These soils are in the Saline Subirrigated range site.

CAPABILITY UNIT VIIe-1 (DRYLAND)

This unit is made up of deep, loose sandy soils that occupy the hilly upland and blown-out areas. In this unit are—

Blown-out land (Bo).
Tivoli fine sand (Tf).

These areas are suited only to limited use as native grass pasture. If used for pasture, Blown-out land must be revegetated. Grazing should be limited on Tivoli fine sand in order to maintain the plant cover; otherwise, this soil

will become Blown-out land or active sand dunes. Grassland management practices needed are proper range use, deferred grazing, rotation-deferred grazing, brush control, and in places, range seeding. The soils in this unit are in the Choppy Sands range site.

CAPABILITY UNIT VIIw-1 (DRYLAND)

This unit consists of soils that occupy the flood plains of the Cimarron River and the channel of the North Fork of the Cimarron River. In this unit are—

Broken land (Bx).
Lincoln soils (Lf).

Because of flooding, the vegetation in these areas is sparse and unstable. The areas are suited only to limited use as native grass pasture. A local representative of the Soil Conservation Service should be consulted for more information about management of these areas. Because of the instability of the soil material and vegetation, Lincoln soils and Broken land are not placed in range sites.

Management of Irrigated Soils [4]

According to the 1959 Census of Agriculture, 8,120 acres were irrigated in Morton County. Probably about 17,000 more acres could be brought under irrigation. An additional 240,000 acres of nearly level soil could also be irrigated if water were available. The two general methods used to apply water in Morton County are gravity irrigation and sprinkler irrigation. The latter is used only where it is impractical to use the gravity method.

Source of irrigation water.—Irrigation water is obtained from deep wells. In 1959 there were 48 irrigation wells in Morton County. More than half of these were drilled between 1954 and 1956. Internal combustion engines, fueled by natural gas or butane, supply power for the turbine pumps that lift the water. The water is lifted from depths ranging from about 70 to 260 feet. Underlying water-bearing formations are continuous throughout the county. Test wells must be drilled, however, to determine the quantity of water that can be obtained at a particular location. The water is excellent for irrigation if it is obtained from the underlying Pliocene and Pleistocene deposits and the Cockrum sandstone formation (*6*). (See fig. 12.)

Suitability of the soils for irrigation.—Some of the soils in the county are well suited to irrigation. (See the "Guide to Mapping Units, Capability Units, and Range Sites" at the back of the report.) The irrigable soils are deep and have adequate moisture-holding capacity. Their permeability is moderate to moderately slow, and internal drainage is good. Before they can be irrigated, most of the soils need to be leveled so that the distribution of water will be uniform. The soils are fertile, and at present, nitrogen is the only plant nutrient needed for peak yields of crops. Management of the soils suited to irrigation is discussed under "Management by Capability Units (Irrigated)."

Crops grown on irrigated soils.—Wheat and grain sorghum, the main crops on irrigated soils, are usually grown year after year. A few acres are used for seed production of native grass, alfalfa, and forage sorghum. Many other crops could be grown if better marketing facilities were available in the county.

Planning an irrigation system.—If a farmer plans to irrigate his land, he should consider the following: (1) The suitability of the soils for irrigation; (2) the adequacy, reliability, and quality of the water supply; (3) the control and conveyance of water; (4) the total water needs based on amount of water used by crops, amount of effective rainfall, and the efficiency of the irrigation system; (5) the method of applying water; and (6) the drainage facilities needed to remove excess surface and subsurface water. A local representative of the Soil Conservation Service should be consulted for further information about irrigating a specific farm.

Management by capability units (irrigated)

In this section the irrigable soils of Morton County have been placed in capability units. In each capability unit are soils that have about the same limitations and risk of damage when used for irrigation. Management practices suitable for the soils in each unit are discussed.

CAPABILITY UNIT I-1 (IRRIGATED)

In this unit are nearly level soils of the upland. They have a loam to clay loam surface soil and subsoil. These fertile soils are deep and have moderately slow permeability. They have a high moisture-holding capacity and are well drained. The soils in this unit are—

Goshen silt loam (Go).
Richfield loam, thick surface, 0 to 1 percent slopes (Rk).
Richfield silt loam, 0 to 1 percent slopes (Rm).
Ulysses silt loam, 0 to 1 percent slopes (Ua).

Good management of these soils includes the following practices that will maintain or improve fertility and tilth: (1) Use of a crop rotation that includes a deep-rooted legume; (2) use of green-manure crops and crop residue; and (3) application of commercial fertilizer, as needed. Land leveling is generally needed to obtain efficient use of water and a better irrigation system. A system that will remove excess irrigation water and runoff from rainstorms is essential.

CAPABILITY UNIT I-2 (IRRIGATED)

This unit consists of nearly level, deep, fertile soils of the upland. These soils have a fine sandy loam surface soil and a sandy clay loam to clay loam subsoil. They have moderately slow permeability and a high moisture-holding capacity, and they are well drained. These soils do not have as much moisture-holding capacity in the upper foot as the soils in capability unit I-1. The soils in this unit are—

Dalhart fine sandy loam, 0 to 1 percent slopes (Da).
Richfield fine sandy loam, 0 to 1 percent slopes (Ra).

Good management of these soils includes the following practices that maintain or improve fertility and tilth: (1) Use of a crop rotation that includes a deep-rooted legume; (2) use of green-manure crops and crop residue; and (3) application of commercial fertilizer, as needed. Land leveling is generally required to provide efficient use of water and a better irrigation system. A system that will remove excess irrigation water and runoff from rainstorms is essential.

CAPABILITY UNIT IIe-2 (IRRIGATED)

This unit consists of gently sloping soils of the upland. They have a fine sandy loam surface layer and a loam to

[4] By Earl Bondy, agronomist, Soil Conservation Service.

sandy clay loam subsoil. These deep, fertile soils have moderately slow permeability and a moderate to high moisture-holding capacity. They are subject to water and wind erosion. The soils in this unit are—

Bridgeport fine sandy loam, 1 to 4 percent slopes (Bp).
Dalhart fine sandy loam, 1 to 3 percent slopes (Db).

Good management of these soils must provide for erosion control, efficient use of water, and maintenance of fertility and tilth. Land leveling and other suitable practices are needed. A system that will remove excess irrigation water and runoff from rainstorms is essential. Distributing water through pipes will eliminate the loss of water that occurs in open irrigation ditches.

CAPABILITY UNIT IIe-4 (IRRIGATED)

This unit consists of gently sloping loamy soils of the upland. They have a silt loam or loam surface layer and subsoil. These deep, fertile soils have moderately slow permeability and high moisture-holding capacity. They are subject to water erosion. The soils in this unit are—

Bridgeport loam, 1 to 3 percent slopes (Br).
Ulysses silt loam, 1 to 3 percent slopes (Ub).

Good management of these soils must provide for erosion control, efficient use of water, and maintenance of fertility and tilth. Land leveling, contour-furrow irrigation, and other practices that lessen the danger of erosion are needed. Drop structures are generally needed to control erosion of the irrigation ditches. A system that will remove excess irrigation water and runoff from rainstorms is essential.

CAPABILITY UNIT IIIe-5 (IRRIGATED)

In this unit are nearly level to gently sloping and undulating soils of the upland. They have a loamy fine sand surface layer and a sandy clay loam to clay loam subsoil. These deep, fertile soils have moderate to moderately slow permeability and a high moisture-holding capacity. They are subject to wind and water erosion. The soils in this unit are—

Dalhart loamy fine sand, 0 to 3 percent slopes (Df).
Richfield loamy fine sand, 0 to 1 percent slopes (Rb).

Good management of these soils provides for erosion control, efficient use of water, and maintenance of fertility. Some of the soils on smooth slopes may be suitable for flood irrigation, but the rest must be irrigated with sprinklers. Many of the areas are uneven or undulating.

CAPABILITY UNIT IVe-7 (IRRIGATED)

Only one soil is in this capability unit. It is a deep, undulating soil of the upland that has a loamy fine sand surface layer and a sandy loam subsoil. It has moderate permeability and a moderate to low moisture-holding capacity. This soil is highly susceptible to wind erosion. The soil in this unit is—

Vona loamy fine sand (Vo).

Good management should provide for erosion control, efficient use of water, and maintenance of fertility. Sprinkler irrigation is generally the only practical method. Tame grasses or a cropping system that provides enough residue to control wind erosion are probably the most suitable.

Productivity of the Soils

This section is about the productivity of the soils used for dryland farming, the dominant type of agriculture.

Crop yields in Morton County depend largely on the climate. Yields of wheat and grain sorghum range from 0 to 50 bushels per acre. The yields usually depend on the amount of rainfall, but they are also affected by diseases, insects, fertility of the soil, and differences in soil management.

Because of the dry climate, the amount of wheat that is abandoned each year is about 40 percent of that planted. Statistics on the acreages and yields per acre of wheat and grain sorghum in stated years are given in table 3. Most of the farms in the county are large and employ low-cost methods. The expenditure per acre is low, and crop production, therefore, can be profitable even though yields per acre are relatively low.

TABLE 3.—*Acreages and yields of wheat and grain sorghum, 1925–58* [1]

Year	Wheat				Grain sorghum	
	Acres planted	Acres harvested	Acres abandoned	Yield per acre harvested	Acres harvested	Yield per acre
			Percent	*Bu.*		*Bu.*
1925	33, 436	11, 034	63. 6	6. 0	27, 362	11. 9
1926	44, 870	40, 383	11. 1	20. 0	34, 970	12. 6
1927	40, 522	2, 431	95. 0	2. 0	50, 765	16. 6
1928	44, 173	28, 712	34. 0	16. 0	41, 572	18. 5
1929	36, 700	33, 030	10. 8	14. 0	27, 316	19. 6
1930	48, 259	33, 009	31. 2	4. 0	25, 166	16. 0
1931	116, 222	112, 735	2. 6	19. 0	36, 373	17. 8
1932	81, 456	59, 463	27. 0	8. 0	33, 039	9. 5
1933	85, 690	6, 855	92. 0	7. 0	32, 884	7. 8
1934	107, 693	53, 847	50. 0	3. 0	(2)	(2)
1935	91, 209	7, 297	92. 0	2. 0	23, 658	1. 0
1936	85, 919	16, 325	81. 0	4. 0	(2)	(2)
1937	147, 000	(2)	(2)	(2)	29, 030	4. 0
1938	15, 000	(2)	(2)	(2)	32, 650	5. 0
1939	120, 000	66, 000	45. 0	5. 5	32, 530	4. 0
1940	81, 000	51, 000	37. 2	5. 8	69, 760	10. 5
1941	94, 000	39, 200	58. 3	6. 9	83, 050	17. 7
1942	87, 000	67, 000	23. 0	13. 2	35, 100	16. 6
1943	88, 000	80, 000	9. 0	13. 0	33, 810	12. 4
1944	82, 000	56, 000	31. 7	15. 3	67, 910	24. 3
1945	94, 000	90, 000	4. 3	15. 9	45, 180	15. 7
1946	91, 000	87, 000	4. 4	12. 5	38, 440	14. 0
1947	132, 000	120, 000	9. 1	20. 2	57, 760	15. 0
1948	138, 000	133, 000	3. 8	20. 8	51, 090	18. 3
1949	133, 000	125, 000	6. 0	13. 5	58, 640	23. 0
1950	116, 000	63, 000	45. 7	5. 8	81, 180	11. 6
1951	124, 000	46, 000	63. 0	11. 0	104, 930	16. 8
1952	110, 000	69, 000	37. 3	13. 7	89, 800	11. 0
1953	124, 000	84, 000	32. 2	7. 4	35, 500	9. 3
1954	94, 000	33, 000	64. 9	6. 0	116, 200	12. 5
1955	109, 000	37, 000	66. 1	10. 1	136, 800	9. 8
1956	89, 000	35, 000	71. 7	8. 9	86, 800	9. 0
1957	21, 000	[3] 5, 000	76. 2	17. 0	184, 000	17. 8
1958	95, 000	90, 000	5. 3	27. 0	111, 000	19. 3
Average, all year	88, 240	55, 666	40. 1	11. 1	59, 822	13. 4

[1] Based on biennial reports of the Kansas State Board of Agriculture.
[2] No figures were given.
[3] Mostly irrigated wheat.

Estimated yields

Estimated yields per acre of dryland wheat and of grain sorghum are given in table 4 for the soils suited to cultivation. In columns A are the yields that can be expected under the present, or prevailing, management. In columns B are yields that can be expected under improved management. For the estimated yields of wheat, it is assumed that a fallow period is used, as that is the general practice. Estimated yields are not given for the soils omitted from table 4 because few or no areas of these soils are being farmed in the county.

The estimated yields are based on limited information. Therefore, the figures given in table 4 are predictions of average yields that may be expected over a period of many years. Such data are considered reliable enough to be of value in farm planning, however. They are based on the following management practices.

TABLE 4.—*Estimated average yields per acre of wheat and grain sorghum on given soils under prevailing and improved management*

Soil	Wheat		Grain sorghum	
	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*
Colby silt loam, 1 to 3 percent slopes	10.5	14.5	11.0	13.0
Dalhart fine sandy loam, 0 to 1 percent slopes	16.0	20.0	20.0	25.0
Dalhart fine sandy loam, 1 to 3 percent slopes	12.0	16.0	16.0	20.0
Dalhart loamy fine sand, 0 to 3 percent slopes	(1)	(1)	23.0	29.0
Goshen silt loam	16.0	20.0	20.0	25.0
Lofton clay loam	9.0	13.0	13.0	15.0
Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded	10.0	14.0	15.0	19.0
Richfield fine sandy loam, 0 to 1 percent slopes	16.0	20.0	20.0	25.0
Richfield loamy fine sand, 0 to 1 percent slopes	(1)	(1)	24.0	30.0
Richfield loam, thick surface, 0 to 1 percent slopes	16.0	20.0	20.0	25.0
Richfield silt loam, 0 to 1 percent slopes	14.5	18.0	15.0	18.0
Ulysses silt loam, 0 to 1 percent slopes	14.0	18.0	15.0	18.0
Ulysses silt loam, 1 to 3 percent slopes	11.5	16.0	12.0	14.5
Ulysses-Colby complex, 1 to 3 percent slopes, eroded	10.5	14.5	11.0	13.0
Vona loamy fine sand	(1)	(1)	13.0	20.0

[1] Little or no wheat grown.

Under prevailing management, if the cropping system is fallow-wheat or sorghum-fallow-wheat, these practices are followed:

1. The soil is tilled several times and is bare when the crop is planted.
2. The grain sorghum is planted too thick.

Under prevailing management, if grain sorghum is grown continuously, these practices are followed:

1. The soil is tilled several times and is bare when the crop is planted.
2. The sorghum is planted too thick.
3. Most of the sorghum residue is grazed off.

Under improved management, if the cropping system is fallow-wheat or sorghum-fallow-wheat, the following practices are used:

1. The soil is tilled only when necessary to control weeds and to prepare seedbeds.
2. Terracing, contouring, and stripcropping are used to help control erosion and to conserve moisture.
3. Tillage implements that leave residue on the surface of the soil are used.
4. Wheat and grain sorghum are planted only if the soil is moist to a depth of more than 24 inches.
5. Two pounds of grain sorghum per acre, or less, are planted.

Under improved management, if grain sorghum is grown continuously, the following practices are used:

1. The soil is tilled only to control weeds and to prepare a seedbed.
2. About 2½ pounds, or less, of grain sorghum per acre are planted.
3. Sorghum residue is not grazed.

Because of so little data, estimated yields for irrigated soils are not provided in this report.

Range Management[5]

Rangeland used for the production of native forage makes up about 31 percent of the total area in Morton County. Generally, the rangeland is not suitable for cultivation. It is scattered throughout the county, but the largest concentration is along the Cimarron River. Nearly 75 percent of the rangeland is in the Cimarron National Grassland District. The work of this district is described in the section "Physical Geography of the County."

The raising of livestock is the third largest agricultural industry in Morton County. Generally, a cow-calf program is followed. Most of the livestock are allowed to graze for approximately 5 months (May to October 1) on the Cimarron National Grassland District. The estimated amount of forage that will be produced determines the number of livestock and the length of the grazing season. Cattle are sold in the fall as grass-fed, or they are put in feedlots. When wheat pastures and grain sorghum stalks or silage are available, yearlings are purchased in the fall (fig. 10). Otherwise, they are not purchased until spring, prior to the turn-in date on the Cimarron National Grassland District.

Range sites and condition classes

Different kinds of range produce different kinds and amounts of grasses and other forage. To manage rangeland properly, an operator should know the different kinds of land (range sites) in his holdings and the plants each site can grow. He will then be able to use the management that produces the best forage plants on each site.

Important terminology used in discussing rangeland is described in the following paragraphs.

Range sites are areas of rangeland that produce significantly different kinds or amounts of climax, or original, vegetation. A significant difference is one great enough to

[5] By PETER N. JENSEN, range conservationist, Soil Conservation Service, Dodge City, Kans.

Figure 10.—**Winter wheat planted on the contour and used for supplemental grazing by Hereford calves.**

require different grazing or other management practices to maintain or improve the present vegetation. *Climax vegetation* is the stabilized plant community on a particular site; it reproduces itself and does not change so long as the environment remains unchanged. Throughout most of the prairie and the plains, the climax vegetation is the combination of plants that was growing there when the region was first settled. If cultivated crops are not to be grown, the most productive combination of forage plants on a range site is generally the climax type of vegetation.

Range condition is a term used to compare the amounts and kinds of vegetation now on a range site with the amounts and kinds that were originally on it. The comparisons are made in percentages. A range site having the original, or climax, vegetation would have a rating of 100 percent, but few range sites have such a rating because their condition has been changed by grazing and drought. Consequently, the four range condition classes are these:

Condition class:	*Percentage of climax vegetation on the site*
Excellent	76–100
Good	51– 75
Fair	26– 50
Poor	0– 25

In the descriptions of range sites, vegetation is referred to in terms of *increasers*, *decreasers*, and *invaders*. Decreasers and increasers are climax plants. Decreasers are the most heavily grazed and are consequently the first to be destroyed by overgrazing. Increasers withstand grazing better, or are less palatable to the livestock; they increase under grazing and replace the decreasers. Increasers finally decrease also, if grazing pressure continues, because when decreasers become depleted, the grazing shifts to increasers. Invaders are plants that become established after the climax vegetation has been reduced by grazing; however, not all are totally useless. Some are good feed at some period of their growth.

The range sites in Morton County are the Sandy, Sands, Choppy Sands, Loamy Upland, Saline Subirrigated, Limy Upland, Rough Breaks-Limy Upland, and Loamy Lowland. The dominant sites—Sands, Sandy, and Loamy Upland—make up about 85 percent of the rangeland.

The description of each range site that follows includes the (1) names and map symbols of the soils in each site; (2) dominant vegetation on the site when it is in excellent condition; and (3) management practices needed to maintain and improve the range condition.

Yields of forage for range sites in excellent condition may be expected to vary with amounts of rainfall received each year. In addition, yields will be influenced by the amount of grazing in past years. Disappearance of forage, other than by grazing, is brought about by rodents, insects, trampling, and other causes. These factors vary from year to year and greatly affect the annual yield of forage.

Following is an estimate of the total forage for the range sites in excellent condition under average rainfall—

Range site:	*Air-dry weight (lb. per acre)*
Sandy	1, 500–2, 000
Sands	2, 000–2, 500
Choppy Sands	1, 250–1, 750
Loamy Upland	1, 250–2, 000
Saline Subirrigated	3, 000–4, 000
Limy Upland	1, 500–2, 250
Rough Breaks	1, 250–1, 750
Loamy Lowland	3, 000–4, 000

SANDY RANGE SITE

This range site is made up of deep, nearly level to moderately steep soils of the upland. The soils have a fine sandy loam surface layer and a sandy loam to clay loam subsoil. They have moderate to moderately slow permeability. The moisture-holding capacity is moderate to high. The soils in this site and the map symbol of each are—

Bridgeport fine sandy loam, 1 to 4 percent slopes (Bp).
Dalhart fine sandy loam, 0 to 1 percent slopes (Da).
Dalhart fine sandy loam, 1 to 3 percent slopes (Db).
Otero fine sandy loam, 5 to 15 percent slopes (Ot).
Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded (Ox).
Richfield fine sandy loam, 0 to 1 percent slopes (Ra).

When the range is in excellent condition, about 55 percent of the plant cover consists of decreasers, mainly sand bluestem, little bluestem, switchgrass, and side-oats grama. Other perennial grasses and forbs make up the rest. The dominant increasers are blue grama, sand dropseed, buffalograss, and sand paspalum. Sand sagebrush and small soapweed are the dominant woody increasers. Common invaders are three-awn, windmillgrass, and six-weeks fescue.

Under present management, this range site is generally in poor condition and is producing approximately one-fourth of its potential in kind and amount of vegetation. In poor range condition, this site produces sand dropseed, sand sagebrush, sand paspalum, and blue grama.

The management practices that maintain or improve the site are proper range use, deferred grazing, rotation-deferred grazing, and range seeding where needed.

SANDS RANGE SITE

This range site is made up of deep, nearly level to undulating soils of the upland (fig. 11). The soils have a loamy fine sand surface layer and a fine sand to clay loam subsoil. The moisture-holding capacity is low to high,

Figure 11.—**A typical view of a Sands range site.**

depending on the texture of the subsoil. The soils in this site and the map symbol for each are—

Dalhart loamy fine sand, 0 to 3 percent slopes (Df).
Richfield loamy fine sand, 0 to 1 percent slopes (Rb).
Tivoli-Vona loamy fine sands (Tv).
Vona loamy fine sand (Vo).

When the range is in excellent condition, about 65 percent of the plant cover consists of decreasers, mainly sand bluestem, little bluestem, switchgrass, side-oats grama, and big sandreed. Other perennial grasses and forbs make up the rest. The dominant increasers include blue grama, sand dropseed, and sand paspalum. Sand sagebrush is the main woody invader. Common invaders are false buffalograss, purple sandgrass, and red lovegrass.

Under present management, this site is generally in poor condition and is producing about one-fourth of its potential in kind and amount of vegetation. In poor condition this site produces mainly sand dropseed, sand sagebrush, sand paspalum, and blue grama.

The management practices that maintain or improve the site are proper range use, deferred grazing, rotation-deferred grazing, brush control, and range seeding where needed.

CHOPPY SANDS RANGE SITE

This range site consists of deep fine sand soils that occupy steep, hummocky, and dune-type sandhills. Many blowouts occur throughout the area. These soils have rapid permeability, are somewhat excessively drained, and are low in moisture-holding capacity. The soils in this site and the map symbol of each are—

Blown-out land (Bo).
Tivoli fine sand (Tf).

When the range is in excellent condition, about 60 percent of the vegetation consists of decreasers, mainly sand bluestem, switchgrass, little bluestem, and big sandreed. Other perennial grasses and forbs make up the rest. The dominant increasers are sand dropseed and sand paspalum. The main woody plant is sand sagebrush. Blowoutgrass and big sandreed are the first perennials to stabilize blowouts or dunes. Common invaders are false buffalograss and purple sandgrass.

Under present management, this range site is generally in poor condition and is producing about one-fourth of its potential in kind and amount of vegetation. In poor condition this site produces dominantly sand dropseed, sand sagebrush, sand paspalum, and blue grama; or it is almost bare of vegetation, except for a few annual plants, such as pigweed and Russian-thistle.

The management practices that maintain or improve the condition of this site are proper range use, deferred grazing, rotation-deferred grazing, brush control, and range seeding where needed. Because of the hazard of wind erosion, water developments and salting grounds should not be located on this site.

LOAMY UPLAND RANGE SITE

This range site consists of deep, nearly level to strongly sloping soils of the upland. The soils have a loam to clay loam surface layer and subsoil. They have slow to moderately slow permeability and a high moisture-holding capacity. The soils in this site and the map symbol of each are—

Bridgeport loam, 1 to 3 percent slopes (Br).
Colby loam, 3 to 8 percent slopes (Cm).
Colby silt loam, 1 to 3 percent slopes (Cb).
Lofton clay loam (Lo).
Richfield loam, thick surface, 0 to 1 percent slopes (Rk).
Richfield silt loam, 0 to 1 percent slopes (Rm).
Ulysses silt loam, 0 to 1 percent slopes (Ua).
Ulysses silt loam, 1 to 3 percent slopes (Ub).

The climax vegetation is mainly a mixture of blue grama, buffalograss, western wheatgrass, side-oats grama, and little bluestem. When the site is heavily grazed, buffalograss is the main increaser. Under normal grazing, blue grama and buffalograss are the dominant grasses. Generally, annuals are the main invaders, but in droughty years pricklypear is the most common invader.

Under present management, the Loamy Upland site is generally in fair to good condition. In this condition it is producing about half its potential in kind and amount of vegetation. The dominant grasses are blue grama and buffalograss.

The management practices that maintain or improve the range condition are proper range use, deferred grazing, and rotation-deferred grazing.

SALINE SUBIRRIGATED RANGE SITE

This site is made up of nearly level, imperfectly drained, saline soils on a part of the Cimarron River flood plains. On an average the texture is sandy loam, but it ranges from clay loam to loamy fine sand. These soils receive extra moisture from the water table and occasional flooding. The soils in this site and the map symbol are—

Las Animas soils (Lc).

When the range is in excellent condition, decreasers make up about 80 percent of the plant cover. These are mainly alkali sacaton, switchgrass, Indiangrass, and western wheatgrass. The dominant increaser is saltgrass. Common invaders are alkali muhly, western ragweed, and tamarisk.

Under present management, the Saline Subirrigated site is generally in good condition.

The management practices that maintain or improve the condition class are proper range use, deferred grazing, and rotation-deferred grazing.

LIMY UPLAND RANGE SITE

This site consists of gently sloping soils of the upland. These soils have a loam to silt loam surface layer and sub-

soil and are calcareous. They have moderately slow permeability, are well drained, and have a high moisture-holding capacity. The complex in this site and the map symbol are—

Ulysses-Colby complex, 1 to 3 percent slopes, eroded (Ue).

The climax plants are mainly a mixture of little bluestem, side-oats grama, blue grama, hairy grama, and buffalograss. The dominant increasers are buffalograss, broom snakeweed, and mat-forming spurges.

Under present management, this range site is generally in poor condition. It is producing about one-fourth of its potential in kind and amount of vegetation.

The management practices that maintain or improve the range condition are proper range use, deferred grazing, rotation-deferred grazing, and range seeding where needed.

ROUGH BREAKS-LIMY UPLAND RANGE SITE

The soil mapping unit, Potter-Mansker complex, is a complex of range sites as well as of soils. Potter soils make up about 50 percent of the mapping unit. They are steep, shallow soils over caliche and limestone and are in the Rough Breaks site. The areas of Mansker loam, about 25 percent, are in the Limy Upland site; other soils present as inclusions in the Potter-Mansker complex are in the Sandy site and the Loamy Upland site.

The Potter soil of the Rough Breaks site is permeable and well drained, but shallow, and therefore has low water-holding capacity.

The climax plants are a mixture of decreasers, such as little bluestem and side-oats grama. In places these climax grasses make up about 60 percent of the composition, and other perennial grasses and forbs make up the rest. Dominant increasers are blue grama, hairy grama, and sand dropseed. Broom snakeweed is a common invader.

Under present management, this complex of range sites is generally in fair condition.

The management practices that maintain or improve the range condition are proper range use, deferred grazing, and rotation-deferred grazing.

LOAMY LOWLAND RANGE SITE

Only one soil is in this range site. It is a nearly level, deep, moderately permeable soil with a silt loam surface layer and a clay loam to loam subsoil. It has a high water-holding capacity. The site receives extra moisture from occasional floods or runoff from high areas. The soil in this site and its map symbol are—

Goshen silt loam (Go).

Decreasers, mainly switchgrass, big bluestem, Indiangrass, Canada wildrye, little bluestem, and side-oats grama, make up at least 55 percent of the climax vegetation. Other perennial grasses and several forbs make up the rest. The dominant increasers are western wheatgrass, blue grama, and buffalograss. Generally, annuals are the main invaders.

Under present management, the Loamy Lowland site is generally in fair condition.

Grazing practices that maintain or improve the range condition are proper range use, deferred grazing, and rotation-deferred grazing.

UNCLASSIFIED

The following mapping units are not true range sites because of the instability of the soil and the vegetation—

Broken land (Bx).
Lincoln soils (Lf).

These areas occupy the flood plains of the Cimarron River and the channel of the North Fork of the Cimarron River. Because of flooding and wind erosion, they have an unstable plant cover. The vegetation consists of switchgrass, side-oats grama, and annual weeds and other grasses. Some cottonwood trees and annual forbs grow on the Lincoln soils.

Principles and Practices of Range Management

High forage production and the conservation of soil, water, and plants on rangeland are obtained through maintenance of range that is in good and excellent condition, and through the improvement of range that is depleted. The vegetation is improved by managing the grazing so as to encourage the growth of the best native forage plants.

Leaf development, root growth, flower-stalk formation, seed production, forage regrowth, and food storage in roots are processes in the development and growth of grass. Range operators must allow these natural processes to take place if maximum yields of forage and peak production of livestock are to be maintained.

Livestock are selective in grazing and constantly seek the more palatable plants. If grazing is not carefully controlled, the better plants are eventually eliminated. Less desirable or second-choice plants will increase. If heavy grazing is continued, even the second-choice plants will be thinned out or eliminated, and undesirable weeds or invaders will take their place.

Research by agricultural workers and the experience of ranchers have shown that when only about half the yearly volume of grass is grazed, damage to the desirable plants is minimized and the range is maintained or improved. The grass that is left to grow has the following effects on the range:

1. Its green living tops manufacture foods (carbohydrates and their products) that provide energy for all plant processes. Unless enough food is manufactured each year for current needs and for storage, the plant cannot start quickly or vigorously the next year.
2. It causes the roots to increase in number and length, so that they can reach additional moisture and plant nutrients. Roots of overgrazed grass do not penetrate to deeply stored moisture because not enough green leaves are left to provide the carbohydrates needed for root growth.
3. It allows the more desirable grasses to crowd out, or to prevent the growth of, the less desirable plants.
4. It provides a mulch that collects the snow and permits the rapid intake and storage of needed moisture.
5. It provides vegetation to protect the soil from wind and water erosion.
6. It provides a greater feed reserve for the dry years and thus removes the need for forced sale of livestock.

Range management requires adjustment in stocking rates from season to season according to the amount of forage produced. It should provide for reserve pastures or other feed during droughts or other periods of low forage production. Thus, the range forage can be grazed moderately at all times. In addition, it often is desirable to keep part of the livestock, such as stocker steers, readily salable. If this is done, the rancher can adjust the number of livestock to the amount of forage produced without the sale of breeding animals.

Management practices that cost little and that are needed to improve all rangeland are defined as follows:

Proper range use.—This is the practice of grazing rangeland at a rate that will maintain vigorous plants, forage reserves, and enough residue to conserve soil and water. In addition, this practice helps to maintain the most desirable vegetation or to improve the quality of vegetation that has deteriorated.

Deferred grazing.—This is the periodic postponement of grazing on a given range. It allows the desirable plants to increase in vigor and number, free from grazing pressure. In addition to improving the range, deferred grazing helps to build up a reserve of forage for later use.

Rotation-deferred grazing.—This is a practice by which one or more pastures are rested at planned intervals throughout the growing season. Each pasture is given a different rest period each successive year so that the desirable forage plants can develop and produce seed every second, third, or fourth year.

Following is a list of practices that improve the range and help to control the movement of livestock:

1. *Range seeding.*—This is the establishment, by seeding or reseeding, of native or improved dominant grasses on land suitable for range. The area to be seeded should have a climate and soil that naturally support range plants so that only management of grazing is needed to maintain forage. A mixture of native grasses, consisting mainly of dominant species in the climax vegetation, should be seeded. Strains of each species that are suited to the area can be used. Only grass seed harvested within 250 to 400 miles south and 100 to 150 miles north of the county should be planted. Grass should be seeded in forage sorghum or grain stubble. This type of cover protects the soil from erosion, provides a firm seedbed, and is relatively free from weeds. The mulch also helps retain moisture in the upper layer of soil. Newly seeded areas should not be grazed for at least 2 years, so that the plants will have time to become firmly established.
2. *Use of water developments.*—Watering places should be located over the entire range, if possible, so that livestock do not have to go too far for water. Good distribution of water helps to achieve uniform use of the range. Generally, wells, ponds, and dugouts supply water for livestock, but in some places water must be hauled. The makeup of each range determines which type of water development is the most practical.
3. *Fencing.*—Fences should be constructed to separate ranges used during different seasons. In some places different range sites are separated if there is a great difference in the way they are used.
4. *Salting.*—This is necessary for livestock. Periodic moving of salting grounds will distribute grazing and promote more uniform use of the range.
5. *Weed and brush control.*—Chemical or mechanical control of undesirable plants may be needed on some sites. This will improve range forage. Sand sagebrush is the dominant undesirable plant in the sandhills of Morton County. A local representative of the Soil Conservation Service should be consulted for further information about weed and brush control.

The management that will obtain high production of livestock and conserve range will—

1. Furnish enough feed and forage to keep livestock in good condition the year round. At appropriate times and in suitable combinations, animals are grazed on the range, are fed concentrates and hay or harvested roughages, and are grazed on tame pasture. To guard against emergencies, surplus feed grown in good years is stored in stacks, pits, or silos. Deferred grazing is practiced to allow grasses to make the growth that will protect the soils, conserve water, and provide reserve grazing.
2. Provide a breeding program that keeps on the range animals of the kind and age that make the best gains. Nonproductive animals are culled out and the herd is continually improved by selective breeding.

Woodland Management

There are no native forests or woodland in Morton County. A sparse, mixed stand of cottonwood, tamarisk, and other trees and shrubs grow on the flood plains along the Cimarron River. Trees and shrubs grow well only in places that receive additional moisture. The only plantings in the county are farmstead windbreaks and trees grown for shade or ornament.

Windbreak plantings help protect farmsteads and feeding areas for livestock. They can be established successfully if they are well planned and cared for. Tillage is needed to control weeds. The diversion of runoff from surrounding areas to the windbreak site will provide additional moisture for the trees. Windbreaks that are irrigated provide protection much sooner than those on dryland. On upland sites a dryland windbreak of conifers and hardwoods should remain effective for 25 to 35 years.

The soil types in Morton County have been arranged in tree (windbreak) planting sites (Silty Upland and Sandy Upland), as shown in the following list. Lincoln soils, Las Animas soils, Potter-Mansker complex, and Tivoli fine sand are not suitable sites for planting trees and therefore are not listed.

Silty Upland	*Sandy Upland*
Bridgeport loam.	Bridgeport fine sandy loam.
Colby loam.	Dalhart fine sandy loam.
Colby silt loam.	Dalhart loamy fine sand.
Goshen silt loam.	Otero fine sandy loam.
Lofton clay loam.	Otero-Manter fine sandy loams.
Richfield loam.	Richfield fine sandy loam.
Richfield silt loam.	Richfield loamy fine sand.
Ulysses silt loam.	Vona loamy fine sand.
Ulysses-Colby complex.	

The species suitable for windbreaks on these sites and their approximate growth in 10 years are given in table 5.

Additional information on planting trees and developing farmstead windbreaks can be obtained from a local representative of the Soil Conservation Service and the county extension agent.

TABLE 5.—*Trees and shrubs suitable for windbreaks on tree planting sites and approximate height attained in 10 years on dryland and irrigated soils*

Suitable trees and shrubs	Silty Upland		Sandy Upland	
	Dry-land	Irri-gated	Dry-land	Irri-gated
	Feet	*Feet*	*Feet*	*Feet*
Russian-olive	12	22	13	22
Osage-orange	12	22	13	22
Tamarisk	10	20	10	15
Mulberry	15	20	17	24
Siberian elm [1]	22	32	25	35
Honeylocust	12	22	14	24
Eastern redcedar	5	9	8	11
Rocky Mountain juniper	5	9	8	11
Ponderosa pine	6	9	8	11
Skunkbush sumac	5	9	6	9

[1] Commonly known as Chinese elm.

Engineering Properties of the Soils [6]

In this section the outstanding engineering properties of the soils are discussed—particularly in relation to highway construction and agricultural engineering. A brief description of the engineering soil classification systems and definitions of engineering terms used in the tables are also given.

Soil properties frequently influence design, construction, and maintenance of engineering structures. The properties most important to engineers are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, texture, plasticity, and pH. Depth of unconsolidated material, depth to water table, and the topography are also important.

The information in this report can be used to—

1. Make soil and land-use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils that will help in the planning of agricultural drainage systems, farm ponds, terraces, waterways, dikes, diversion terraces, irrigation canals, and irrigation systems.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations of selected locations.
4. Locate probable sources of gravel, sand, and other construction materials.
5. Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in maintaining the structures. The information may also prove useful as a guide in future planning.
6. Determine the suitability of soils for the cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps, reports, and aerial photographs for the purpose of making maps and reports that will be more useful to engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

This report will not eliminate the need for, or take the place of, on-site sampling and testing of soils for design and construction of specific engineering works. It may be useful in planning more detailed field surveys to determine the in-place condition of the soil at the site of the proposed construction.

Some terms used in soil science may have a different meaning than those used in engineering. Many of these terms are defined in the Glossary. Some of the terms used by engineers are defined in this section.

Engineering Classification Systems

In this section the soil material in the horizons of a typical profile of each soil type is classified in three systems—USDA, AASHO, and Unified.

The USDA system is the textural classification (*10*) used by the Soil Conservation Service in soil surveys.

The American Association of State Highway Officials (AASHO) (*1*) has developed a system of classifying soils that is based on field performance of highways (*7*). It is the system most widely used in highway construction. In this system, soil materials are classified in seven groups according to physical properties of the soil materials. These groups range from A–1 for the best soils for road subgrades to A–7 for the poorest. These basic groups have been divided into subgroups (for example, A–2–4) to which can be added a number that approximates within-group evaluations (for example, A–2–4(0)). Group indexes range from 0 for the best soils for subgrades to 20 for the poorest. In the next to last column of table 8, they are shown in parentheses following the soil group or subgroup symbol. Only the group and subgroup classification is estimated in table 6 for soils in Morton County.

The basic soil groups are placed in two major categories: (1) *Granular materials* (35 percent or less passing No. 200 sieve) and (2) *silt-clay materials* (more than 35 percent passing No. 200 sieve).

A–1, A–2, and A–3 soils are classified as granular materials. A–1 soils consist of coarse-to-fine, well-graded mixtures of sand and gravel that are nonplastic or feebly plastic. In well-graded materials, there are no sizes lacking and no excess of material in any size range. The A–1 soils also include predominantly coarse materials. A–1–b soils include those materials that consist dominantly of coarse sand.

A–2 soils consist of a wide range of granular materials that cannot be classified as A–1 or A–3 because of fines

[6] By CARL L. ANDERSON, engineer, Soil Conservation Service, Garden City, Kans.

content, plasticity, or both. A–2–4 soils include those granular materials that have plasticity characteristics of the A–4 group.

A–3 soils consist primarily of fine sands and are deficient in material passing the No. 200 sieve.

In this county A–4, A–6, and A–7 soils are classified as silt-clay materials.

A–4 soils are composed predominantly of silt. Only moderate to small amounts of coarse material and only small amounts of sticky colloidal clay are present.

A–6 soils are composed mainly of clay and moderate to negligible amounts of coarse material.

A–7 soils are composed mainly of clay, as are the A–6 soils, but are elastic because of the presence of one-size silt particles, organic matter, mica flakes, or lime carbonate. A–7–6 soils represent those A–7 soils that have a high plasticity index in relation to liquid limit.

Some engineers prefer to use the Unified soil classification system (*11*). In this system, soil material is divided into 15 classes: 8 classes are for coarse-grained material (GW, GP, GM, GC, SW, SP, SM, SC), 6 classes are for fine-grained material (ML, CL, OL, MH, CH, OH), and 1 class is for highly organic material (Pt). Mechanical analyses are used to determine the GW, GP, SW, and SP classes of material; mechanical analyses, liquid limit, and plasticity index are used to determine GM, GC, SM, SC, and the fine-grained soils (ML, CL, OL, MH, CH, OH). The soils of this county have been classified only in the SW, SP, SM, SC, ML, CL, and CH classes of material.

An outline of the major divisions and brief definitions for the soil group symbols of the Unified soil classification system used in this survey are:

Coarse-grained soils (more than half of material is retained on the No. 200 sieve):
- Sands (more than half of coarse fraction passes the No. 4 sieve):
  - *Clean sands* (little or no fines):
    - SW Well-graded sands, gravelly sands.
    - SP Poorly graded sands, gravelly sands.
  - *Sands with fines* (appreciable amount of fines):
    - SM Silty sands, sand-silt mixtures.
    - SC Clayey sands, sand-clay mixtures.

TABLE 6.—*Brief descriptions and the*

Map symbol	Soil	Description	Depth from surface
			Inches
Bo	Blown-out land.	Sand or loamy sand that is actively eroding or blowing; generally is 5 feet or more thick; underlain by loam or clay loam at some depth between 5 and 20 feet; refer to Tivoli fine sand and loamy fine sand for estimated properties.	Variable.
Bp	Bridgeport fine sandy loam, 1 to 4 percent slopes.	Well-drained soil; has convex, stable slopes; consists of 6 to 20 inches of fine sandy loam underlain by more than 4 feet of colluvial-alluvial material of loam or clay loam texture.	0–13 13–48
Br	Bridgeport loam, 1 to 3 percent slopes.	Same as Bridgeport fine sandy loam, 1 to 4 percent slopes, except that the top 6 to 10 inches is loam.	0–10
Bx	Broken land.	This land type comprises the channel and banks of the North Fork of the Cimarron River.	Variable.
Cm Cb	Colby loam, 3 to 8 percent slopes. Colby silt loam, 1 to 3 percent slopes.	Well-drained soils of the upland; have convex, stable slopes; consist of 3 to 6 inches of loam or silt loam underlain by more than 4 feet of calcareous loam or silt loam (loess).	0–4 4–48
Da Db	Dalhart fine sandy loam, 0 to 1 percent slopes. Dalhart fine sandy loam, 1 to 3 percent slopes.	Well-drained soils of the upland; consists of 6 to 12 inches of fine sandy loam over 12 to 24 inches of sandy clay loam that is underlain by more than 3 feet of loam or clay loam; in places buried soil horizons occur below 24 inches; parent material was deposited by wind.	0–12 12–36 36–60
Df	Dalhart loamy fine sand, 0 to 3 percent slopes.	Same as Dalhart soils just described, except that top 6 to 16 inches is loamy fine sand; soil occurs mostly in undulating areas.	0–12
Go	Goshen silt loam.	Well-drained soil that occupies the nearly level flood plains along the North Fork of the Cimarron River and is occasionally flooded; is forming in calcareous alluvium; consists of 8 to 20 inches of silt loam or loam underlain by more than 3 feet of loam or silt loam.	0–14 14–48
Lc	Las Animas soils.	Imperfectly drained soils that occupy part of the flood plains of the Cimarron River and are occasionally inundated; depth to water table ranges from 1 to 6 feet; soils consist of 12 to 24 inches of sandy loam underlain by more than 3 feet of sand.	0–18 18–48
Lf	Lincoln soils.	Imperfectly drained soils that occupy part of the flood plains of the Cimarron River; occur on gently undulating slopes of 0 to 3 percent; occasionally flooded; depth to water table ranges from 0 to 6 feet; soils consist of 3 to 6 inches of loamy sand underlain by more than 4 feet of stratified fine, medium, and coarse sand.	0–6 6–48

Fine-grained soils (more than half of material passes the No. 200 sieve):

Silts and clays (liquid limit less than 50):

- ML Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts with slight plasticity.
- CL Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays.

Silts and clays (liquid limit greater than 50):

- CH Inorganic clays of high plasticity and fat clays.

Engineering Properties of the Soils and Soil Test Data

Three tables are in this section. In the first (table 6), the soils are briefly described and their physical properties important to engineering are estimated. In the second (table 7), some engineering interpretations are given. In the third (table 8), soil test data are given for six soils.

The estimated properties in table 6 are given for a typical profile, generally of each soil series. They are based on laboratory tests on soils from Morton and Logan Counties, on tests by the State Highway Commission of Kansas at construction sites, on experience with the same kind of soils in other counties, and on the information in other sections of this report. The estimated physical properties are those of the average soil profile; hence variation from these values should be anticipated.

In table 6 the soil profile is divided into significant layers (horizons), and the depth from the surface is given in inches. More complete profile descriptions are given in the section "Genesis and Morphology of the Soils."

In table 6 textural classes of the United States Department of Agriculture and estimates of the Unified and AASHO classifications are given. The columns under the heading "Percentage passing sieve" show the percentage of soil material that is smaller in diameter than the openings of the given screen. The grain-size analysis in this table is based on tests made by a combination of the sieve and hydrometer methods.

estimated physical properties of the soils

Classification			Percentage passing sieve—		Permeability	Available water capacity	Shrink-swell potential
USDA texture	Unified	AASHO	No. 10	No. 200			
					Inches per hour	*Inches per inch of soil*	
Fine sandy loam	SM	A-2-4	100	15-25	1.0-2.0	0.10	Low.
Loam or clay loam	ML-CL	A-6 or A-7-6	100	75-90	0.2-0.5	.19	Moderate.
Loam	ML-CL	A-6 or A-4	100	70-85	0.5-1.0	.18	Moderate to low.
Loam or silt loam	ML-CL	A-6 or A-4	100	70-85	0.5-1.0	.18	Low to moderate.
Loam or silt loam	ML-CL	A-7-6 or A-6	100	75-90	0.2-0.5	.18	Moderate.
Fine sandy loam	SM	A-2-4	100	20-35	1.0-2.0	.10	Low.
Sandy clay loam	SM-SC or SC	A-2-4	100	30-45	0.5-1.0	.18	Low.
Loam or clay loam	ML-CL or CL	A-6 or A-4	100	75-95	0.2-0.5	.19	Low to moderate.
Loamy fine sand	SM	A-2-4	100	10-25	2.0-5.0	.07	Low.
Silt loam or loam	ML-CL	A-6 or A-7-6	100	75-95	0.2-0.5	.18	Moderate.
Loam or silt loam	ML-CL	A-6 or A-4	100	75-90	0.2-0.5	.18	Low to moderate.
Sandy loam	SM	A-2-4	100	10-30	1.0-2.0	.10	Low.
Sand	SW or SM-SW	A-1-b	90-95	0-10	5.0+	.04	Low.
Loamy sand	SM or SM-SW	A-1-b	100	5-15	2.0-5.0	.07	Low.
Sand	SW or SM-SW	A-1-b	90-95	0-10	5.0+	.04	Low.

TABLE 6.—*Brief descriptions and the estimated*

Map symbol	Soil	Description	Depth from surface
			Inches
Lo	Lofton clay loam.	Occupies upland depressions that are generally ponded after rainstorms; has concave or plane slopes of 0 to 1 percent; consists of 4 to 10 inches of clay loam over 12 to 24 inches of clay that is underlain by more than 3 feet of loam or silt loam; in a few depressions there is a fine sandy loam surface layer.	0–8 8–24 24–60
Ot	Otero fine sandy loam, 5 to 15 percent slopes.	Well-drained soil of the upland; has convex, stable slopes; composed of more than 4 feet of calcareous fine sandy loam; a few pockets of gravelly material occur in places; parent material is old alluvium.	0–48
Ox	Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded.	This complex is comprised of about 60 percent Otero fine sandy loam and 30 percent Manter fine sandy loam; occurs on gently undulating areas; estimated properties for Manter fine sandy loam are the same as for Otero fine sandy loam, 5 to 15 percent slopes.	
Px	Potter-Mansker complex:		
	Potter loam.	This soil comprises about 50 percent of the complex; has steep to broken slopes; consists of less than 10 inches of highly calcareous loam over caliche of the Ogallala formation.	0–8
	Mansker loam.	This soil comprises about 25 percent of the complex; has moderate to steep slopes; consists of 15 to 30 inches of highly calcareous loam or clay loam over caliche similar to that underlying Potter loam.	0–24
	Colby and Otero soils.	These soils comprise the remaining 25 percent of the complex; for estimated properties of the Colby soils, see Colby loam and Colby silt loam; for estimated properties of the Otero soils, see Otero fine sandy loam, 5 to 15 percent slopes.	
Ra	Richfield fine sandy loam, 0 to 1 percent slopes.	Well-drained soil of the upland; occurs on long, smooth slopes; consists of 6 to 12 inches of fine sandy loam over 12 to 20 inches of clay loam that is underlain by more than 3 feet of loam or clay loam.	0–10 10–26 26–60
Rb	Richfield loamy fine sand, 0 to 1 percent slopes.	Same as Richfield soil just described, except that the uppermost 6 to 14 inches is a loamy fine sand.	0–10
Rk	Richfield loam, thick surface, 0 to 1 percent slopes.	Same as Richfield fine sandy loam, 0 to 1 percent slopes, except that the uppermost 6 to 12 inches is a loam.	0–10
Rm	Richfield silt loam, 0 to 1 percent slopes.	Well-drained soil of the upland; ccurs on long, smooth slopes; consists of 4 to 10 inches of silt loam over 8 to 16 inches of silty clay loam that is underlain by more than 4 feet of silt loam or loam (loess).	0–6 6–20 20–54
Tf	Tivoli fine sand.	Excessively drained soil of the upland; occurs in duned areas with 10 to 25 percent slopes; consists of more than 5 feet of fine sand.	0–60
Tv	Tivoli-Vona loamy fine sands.	This complex consists of at least 65 percent Tivoli loamy fine sand and about 25 percent Vona loamy fine sand; occurs in rolling to hilly areas with 5 to 20 percent slopes; refer to Tivoli fine sand and Vona loamy fine sand for estimated properties.	
Ua Ub	Ulysses silt loam, 0 to 1 percent slopes. Ulysses silt loam, 1 to 3 percent slopes.	Well-drained soils of the upland; occur on convex slopes; consist of 6 to 10 inches of silt loam underlain by more than 4 feet of silt loam or loam (loess or similar textured old alluvium).	0–8 8–60
Ue	Ulysses-Colby complex, 1 to 3 percent slopes, eroded.	This complex consists of about 60 percent Ulysses soils and 30 percent Colby soils; occurs on single and undulating slopes; refer to Ulysses silt loams and Colby loam and Colby silt loam for estimated properties.	
Vo	Vona loamy fine sand	Well-drained soil on rolling, subdued dunes with slopes of 1 to 5 percent; consists of 6 to 20 inches of loamy fine sand over 10 to 30 inches of fine sandy loam that is underlain by 2 feet or more of loamy fine sand; in places loam or clay loam occurs below 3 feet.	0–10 10–30 30–60

physical properties of the soils—Continued

Classification			Percentage passing sieve—		Permea-bility	Available water capacity	Shrink-swell potential
USDA texture	Unified	AASHO	No. 10	No. 200			
					Inches per hour	*Inches per inch of soil*	
Clay loam	CL	A-7-6	100	95-100	0. 2-0. 5	0. 19	Moderate or high.
Clay	CH	A-7-6	100	95-100	0. 05	. 21	High.
Loam or silt loam	ML-CL	A-7-6	100	95-100	0. 2-0. 5	. 19	Moderate.
Fine sandy loam	SM	A-2-4	100	20-35	1. 0-2. 0	. 10	Low.
Loam	CL	A 6	85-95	50-70	0. 5-1. 0	. 16	Moderate.
Loam	CL	A-6	85-95	50-70	0. 5-1. 0	. 16	Moderate.
Fine sandy loam	SM or SM-SC	A-2-4	100	20-35	1. 0-2. 0	. 10	Low.
Clay loam	CL	A-6	100	65-85	0. 2-0. 5	. 19	Moderate.
Loam or clay loam	CL	A-6 or A-4	100	75-95	0. 2-0. 5	. 19	Moderate.
Loamy fine sand	SM	A-2-4	100	10-25	2. 0-5. 0	. 07	Low.
Loam	ML-CL	A-6 or A-4	100	70-85	0. 5-1. 0	. 18	Low to moderate.
Silt loam	CL or ML-CL	A-6 or A-4	100	85-95	0. 2-0. 5	. 19	Moderate.
Silty clay loam	CL	A-7-6	100	90-100	0. 2-0. 5	. 20	Moderate.
Silt loam	ML-CL	A-7-6 or A-6	100	90-100	0. 2-0. 5	. 19	Moderate.
Fine sand	SP-SM or SM	A-2-4 or A-3	100	5-10	5. 0+	. 04	Low.
Silt loam	ML-CL or CL	A-6	100	85-95	0. 2-0. 5	. 19	Moderate.
Silt loam	CL or ML-CL	A-7-6 or A-6	100	90-100	0. 2-0. 5	. 19	High or moderate.
Loamy fine sand	SM	A-2-4	100	12-25	2. 0-5. 0	. 07	Low.
Fine sandy loam	SM or SM-SC	A-2-4	100	15-30	1. 0-2. 0	. 10	Low.
Loamy fine sand	SM	A-2-4	100	12-25	2. 0-5. 0	. 07	Low.

TABLE 7.—*Engineering*

Soil series and map symbol	Suitability as source of— Topsoil	Suitability as source of— Sand	Suitability as source of— Gravel	Suitability for— Road fill [1]	Suitability for— Subgrade [1]
Bridgeport (Bp, Br)	Surface layer is fair; other layers are good.	Not suitable	Not suitable (in places a few pockets occur below 4 feet).	Good	Fair
Colby (Cb, Cm)	Good	Not suitable	Not suitable	Good	Good
Dalhart (Da, Db, Df)	Loamy fine sand surface layer is poor; fine sandy loam layer is fair.	Not suitable	Not suitable	Good	Uppermost 2 feet are good; clay loam substrata are fair alone and poor when mixed.
Goshen (Go)	Good	Not suitable	Not suitable	Good	Fair
Las Animas (Lc)	Poor	Good below 2 feet (high water table; poorly graded).	Poor (localized pockets).	Good	Poor to good
Lincoln (Lf)	Not suitable	Good (high water table; poorly graded).	Poor (localized pockets).	Fair to good	Poor to good
Lofton (Lo)	Fair	Not suitable	Not suitable	Poor	Poor
Mansker (Px)	Surface layer is fair	Not suitable	Not suitable	Good	Poor
Manter (Ox)	Fair	Not suitable	Not suitable	Good	Good

See footnotes on pages 30 and 31.

interpretations of the soils

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
	Reservoir area	Embankment				
Well drained	Deep; moderate permeability.	Low to moderate shear strength and stability; moderate to high compressibility; poor to fair compaction.	Well drained	Deep; well drained; high water-holding capacity; moderate permeability.	Deep; moderate erodibility; low to moderate stability; moderate permeability.	Deep; moderate erodibility; low to moderate stability.
Well drained	Deep; moderate permeability; sand occurs in places in the stream channels.	Low to moderate shear strength and stability; moderate to high compressibility; poor to fair compaction.	Well drained; sloping.	Deep; high water-holding capacity.	Moderate to high erodibility; moderate permeability.	Low to moderate stability; moderate to high erodibility.
Well drained	(2)	(2)	Well drained	Deep; moderate permeability; moderate to high water-holding capacity.	Moderate to high erodibility; low to moderate stability.	Moderate to high erodibility; low to moderate stability.
Well drained	(2)	(2)	Well drained	Deep; moderate permeability.	(2)	Moderate stability and erodibility.
High water table; stratified material in top 2 feet and sand below.	(2)	(2)	Imperfectly drained; seasonally high water table.	Subject to flooding; moderately deep over sand.	(2)	(2).
High water table; flooding hazard; high erodibility.	(2)	(2)	(2)	Low water-holding capacity; subject to flooding.	(2)	(2).
Ponding of water.	Slow permeability; moderate to high shrink-swell potential; deep.	(2)	Ponding of water; no outlets.	Ponding of water in depressions with concave slopes.	(2)	(2).
Well drained	(2)	(2)	(2)	(2)	(2)	(2).
Well drained	(2)	(2)	Well drained	(2)	(2)	(2).

TABLE 7.—*Engineering interpretations*

Soil series and map symbol	Suitability as source of—			Suitability for—	
	Topsoil	Sand	Gravel	Road fill [1]	Subgrade [1]
Otero (Ot, Ox)	Fair	Not suitable	Not suitable (a few pockets in places).	Good	Good
Potter (Px)	Surface layer is fair	Not suitable	Fair (localized pockets).	Good	Poor
Richfield (Ra, Rb, Rk, Rm).	Good, but loamy fine sand surface layer is poor; fine sandy loam surface layer is fair.	Not suitable	Not suitable	Fair to good	Poor to fair
Tivoli (Tf, Tv)	Not suitable	Not suitable	Not suitable	Good if confined.	Good if confined
Ulysses (Ua, Ub, Ue)	Good	Not suitable	Not suitable	Good	Fair to good
Vona (Vo)	Surface layer is poor	Not suitable	Not suitable	Good	Good

[1] This column prepared with assistance from C. W. HECKATHORN, field soils engineer, and HERBERT E. WORLEY, soils research engineer, Kansas State Highway Commission.

of the soils —Continued

Soil features affecting—							
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankment	Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
Well drained	Deep; moderate permeability; sand strata in places.	Moderate shear strength and stability; high compressibility; good compaction.	(2)	(2)	Moderate to high erodibility; sloping; low to moderate stability.	Moderate to high erodibility; low to moderate stability.
Well drained	Mostly soft limestone with pockets of sand and gravel; moderate permeability.	Moderate shear strength and stability; low plasticity.	(2)	(2)	(2)	(2).
Well drained	Deep; moderate permeability.	Moderate shear strength and stability; fair to good compaction; moderate to high compressibility.	Well drained	Deep; moderate permeability; high water-holding capacity; nearly level.	Low to moderate erodibility; moderate stability.	Moderate stability; low to moderate erodibility.
High erodibility.	(2)	Moderate to rapid permeability; high erodibility; moderate shear strength.	(2).	(2)	(2)	(2).
Well drained	Deep; moderate permeability.	Low to moderate shear strength, stability, and erodibility; fair to good compaction; moderate to high shrink-swell potential.	Well drained; deep.	Deep; moderate permeability; high water-holding capacity.	Deep; low to moderate erodibility and stability.	Deep; low to moderate erodibility and stability.
High erodibility.	(2)	Moderate permeability; moderate shear strength and stability; good compaction; low plasticity.	(2)	Deep; low to moderate water-holding capacity.	(2)	(2).

[2] Practice not applicable to this soil series.

TABLE 8.—*Engineering*

Soil name and location	Parent material	Kansas report number (S–60)	Depth	Horizon	Moisture density [2]: Maximum dry density	Moisture density [2]: Optimum moisture content
			Inches		*Lb. per cu. ft.*	*Percent*
Dalhart loamy fine sand:						
1,150 feet east and 150 feet south of northwest corner NE¼ sec. 29, T. 34 S., R. 41 W. (Modal profile.)	Sand-mantled High Plains.	65–14–1	0–7	A_1	114	10
		65–14–2	11–24	B_2	119	12
		65–14–3	38–70	C	121	8
1,000 feet west and 100 feet south of northeast corner NE¼ sec. 7, T. 34 S., R. 40 W. (Sandier B horizon.)	Sand-mantled High Plains.	65–13–1	0–9	A_1	112	7
		65–13–2	13–22	B_2	120	10
		65–13–3	22–46	C_1	124	9
100 feet west and 50 feet north of southeast corner SW¼ sec. 1, T. 34 S., R. 41 W. (Clayey B horizon.)	Sand-mantled High Plains.	65–12–1	0–12	A_1	113	8
		65–12–2	22–37	B_2	119	12
		65–12–3	55–85	C_1	109	13
Richfield fine sandy loam:						
200 feet north and 225 feet east of southwest corner SW¼ sec. 20, T. 33 S., R. 39 W. (Modal profile.)	Eolian sand over loess.	65–7–1	4–8	A_1	120	10
		65–7–2	13–22	B_2	105	16
		65–7–3	42–56	C_1	105	17
1,300 feet north and 900 feet east of southwest corner SW¼ sec. 34, T. 34 S., R. 42 W. (Modal profile.)	Eolian sand over loess.	65–8–1	2–7	A_{12}	117	9
		65–8–2	13–24	B_2	104	18
		65–8–3	40–93	C_1	110	16
Richfield silt loam:						
400 feet north and 200 feet west of southeast corner SE¼ sec. 6, T. 32 S., R. 42 W.	Loess.	65–4–1	3–8	A_{12}	106	16
		65–4–2	8–16	B_2	95	24
		65–4–3	16–28	B_{3ca}	98	21
		65–4–4	35–62	C_1	97	21
800 feet south and 150 feet east of northwest corner SW¼ sec. 23, T. 32 S., R. 42 W.	Loess.	65–5–1	0–5	A_{1p}	101	18
		65–5–2	5–14	B_2	99	23
		65–5–3	14–25	B_{3ca}	97	21
		65–5–4	34–56	C_1	100	21
Tivoli fine sand:						
600 feet north and 100 feet west of southeast corner SE¼ sec. 8, T. 34 S., R. 42 W. (Modal profile.)	Dune sand.	65–1–1	0–6	A_1	112	8
		65–1–2	6–62	C_1	104	12
1,450 feet west and 700 feet south of northeast corner SE¼ sec. 4, T. 34 S., R. 42 W. (Modal profile.)	Dune sand.	65–2–1	0–4	A_1	116	10
		65–2–2	4–64	C	105	12
Ulysses silt loam:						
800 feet south and 400 feet west of northeast corner NE¼ sec. 36, T. 33 S., R. 43 W. (Modal profile.)	Loess.	65–3–1	0–6	A_1	97	23
		65–3–2	6–15	AC or B_2	97	21
		65–3–3	32–54	C_1	97	19
300 feet south and 400 feet east of northwest corner NW¼ sec. 20, T. 33 S., R. 41 W. (Modal profile.)	Loess.	65–6–1	0–7	A_1	103	18
		65–6–2	7–19	AC or B_2	100	22
		65–6–3	34–54	C_1	101	21
Vona loamy fine sand:						
600 feet east and 600 feet south of northwest corner SW¼ sec. 30, T. 34 S., R. 40 W. (Modal profile.)	Sand-mantled High Plains.	65–10–1	0–9	A_1	114	7
		65–10–2	9–18	B_2	116	9
		65–10–3	18–36	C	114	11
450 feet west of northeast corner NW¼ sec. 25, T. 34 S., R. 41 W. (Sandier B horizon.)	Sand-mantled High Plains.	65–11–1	0–7	A_1	114	8
		65–11–2	7–15	B_2	118	9
		65–11–3	15–48	C_1	115	10
600 feet east and 100 feet north of southwest corner SW¼ sec. 29, T. 34 S., R. 40 W. (Clayey B horizon.)	Sand-mantled High Plains.	65–9–1	0–7	A_1	122	9
		65–9–2	7–14	B_2	118	12
		65–9–3	14–48	C_1	117	8

[1] Tests performed by the State Highway Commission of Kansas in accordance with standard procedure of the American Association of State Highway Officials (AASHO) (*1*), except as stated in footnotes 2 and 3.

[2] Based on the Moisture-density Relations of Soils Using a 5.5-lb. Rammer and a 12-in. Drop, AASHO Designation: T 99–57, Method A (*1*), with the following variations: (1) All material is oven dried at 230° F.; (2) all material is crushed in laboratory crusher after drying; and (3) no time is allowed for dispersion of moisture after mixing with soil material.

[3] Mechanical analyses according to AASHO Designation: T 88 (*1*) with the following variations: (1) All material is oven dried at 230° F., and crushed in laboratory crusher; (2) sample is not soaked prior to dispersion; (3) sodium silicate is used as dispersing agent; and (4) dispersing time, in minutes, is established by dividing the plasticity index value by 2; the maximum time is 15 minutes, and the minimum, 1 minute. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the

test data [1]

Mechanical analyses [3]							Liquid limit	Plasticity index	Classification	
Percentage of fraction passing sieve [4]—			Percentage smaller than—						AASHO [5]	Unified [6]
No. 40 (0.42 mm.)	No. 60 (0.250 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
93	54	16	10	5	4	4	16	1	A 2-4(0)	SM.
94	74	44	32	22	13	8	22	8	A-4(2)	SC.
92	64	20	15	9	5	3	16	2	A-2-4(0)	SM.
95	61	14	10	9	6	6	17	3	A-2-4(0)	SM.
92	77	34	24	14	6	4	21	5	A-2-4(0)	SM-SC.
97	67	28	19	12	6	6	17	4	A-2-4(0)	SM-SC.
92	62	15	11	7	5	4	16	1	A-2-4(0)	SM.
93	73	46	35	23	11	7	23	8	A-4(2)	SC.
97	86	68	58	38	16	8	28	9	A-4(7)	CL.
96	80	33	21	12	6	5	18	4	A-2-4(0)	SM-SC.
99	91	72	59	43	24	14	34	17	A-6(10)	CL.
100	99	96	86	56	30	19	35	14	A-6(10)	CL.
95	79	21	20	13	6	6	20	13	A-2-4(0)	SM.
98	94	68	63	48	28	20	36	7	A 6(9)	CL.
99	97	77	60	42	16	8	30	12	A-6(9)	CL.
99	96	89	70	38	12	5	29	9	A-4(8)	CL.
99	98	94	83	62	38	26	48	23	A-7-6(15)	CL.
----	100	99	94	70	37	24	43	18	A-7-6(12)	ML-CL.
----	100	99	88	58	27	16	43	18	A-7-6(12)	ML-CL.
99	99	95	80	48	19	10	34	11	A-6(8)	ML-CL.
----	100	98	90	71	42	27	54	29	A-7-6(18)	CH.
----	100	99	92	61	32	29	47	24	A-7-6(15)	CL.
99	99	99	96	70	26	12	44	19	A-7-6(12)	ML-CL.
93	54	16	11	6	4	3	17	1	A-2-4(0)	SM.
95	59	5	4	4	3	2	19	1	A-2-4(0)	SP-SM.
91	50	20	13	5	4	4	13	0	A-2-4(0)	SM.
93	60	8	8	6	6	5	19	0	A-3(0)	SP-SM.
99	97	93	81	52	27	18	40	16	A-6(10)	ML-CL.
100	99	96	88	66	36	22	50	27	A-7-6(17)	CL.
100	99	97	92	70	32	22	43	19	A-7-6(12)	CL.
100	99	93	73	45	23	14	35	19	A-6(12)	CL.
----	100	98	80	52	28	18	45	21	A-7-6(13)	CL.
----	100	99	87	59	25	14	42	18	A-7-6(12)	ML-CL.
94	75	16	15	11	7	5	18	1	A-2-4(0)	SM.
98	82	20	18	14	8	7	19	2	A-2-4(0)	SM.
96	72	13	12	8	6	4	18	1	A-2-4(0)	SM.
88	54	15	10	7	7	7	18	2	A-2-4(0)	SM.
93	68	19	16	12	6	5	19	3	A-2-4(0)	SM.
95	55	16	14	9	4	3	18	1	A-2-4(0)	SM.
90	66	24	18	12	7	5	17	2	A-2-4(0)	SM.
96	72	34	27	17	8	5	22	8	A-2-4(0)	SC.
87	65	14	13	9	5	4	17	1	A-2-4(0)	SM.

hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[4] All listed soils have 100 percent passing No. 10 sieve.

[5] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1, ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145-49 (*1*).

[6] Based on The Unified Soil Classification System, Technical Memorandum No. 3-357, v. 1, Waterways Experiment Station, Corps of Engineers, March 1953 (*11*).

The column headed "Permeability" gives the estimated rate, expressed in inches per hour, that water moves through a soil that is not compacted. The permeability of a soil depends largely upon the soil texture and structure.

In the column headed "Available water capacity" are estimates, in inches per inch of soil, of the capillary water in the soil when it is wet to field capacity. When the soil is air dry, this amount of water will wet the soil material to a depth of 1 inch without deeper percolation.

The column headed "Shrink-swell potential" gives a rating of the volume change of soil when changes take place in its water content. It is an estimate of how much a soil shrinks and swells under extremes of dryness and wetness. An example of a soil that has a high shrink-swell potential is Lofton clay loam. This soil shrinks greatly when it is dry and swells when it is wet. Tivoli fine sand is an example of a soil having low to very low shrink-swell potential. A knowledge of this potential is important in planning the use of a soil for building roads and other engineering structures.

The depth to the water table is given in table 6 under the heading "Description" for those soils that are affected by a high water table.

Reaction of the soils in the county ranges from neutral to moderately alkaline. The pH of the surface layer and subsoil varies from 7.0 to 8.5. The substratum of most of the soils is moderately alkaline with a pH of 7.9 to 8.5.

Table 7 indicates the suitability of the soils in Morton County for various engineering uses. In this table are given soil features that affect use of the soils for highway construction and for agricultural engineering.

The suitability of the soil for topsoil is given because this information is important in growing vegetation needed for erosion control on embankments, road shoulders, ditches, and cut slopes. Each layer of the soil profile was considered as a possible source of material usable as topsoil for these estimates. The surface layer may have a different rating than the subsoil because of clayey, sandy, or caliche material. The loamy soils on cut slopes can usually be seeded without an added layer of topsoil. If vegetation is to be grown on cut slopes of the more sandy Tivoli and Vona soils, a layer of suitable topsoil is needed.

The suitability of the soil materials for road subgrade and road fill depends largely on the texture of the soil materials and their natural water content. Highly plastic soil materials are rated "Poor" for road subgrade and "Poor" or "Fair" for road fill, depending on the natural water content of the soil materials and how well they can be handled, dried, and compacted.

Sand and gravel in commercial quantities are found in localized pockets in areas of Potter-Mansker, Lincoln, Las Animas, and Otero soils.

As shown in table 8, samples from 14 profiles of 6 of the principal soils of Morton County were tested by the standard AASHO procedures to help evaluate the soils for engineering purposes. Only selected layers of each soil were sampled.

The results of moisture-density tests are given in this table. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of a compacted material will increase until the optimum moisture content is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "maximum dry density." Moisture-density data are important in earthwork, for as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

Tests for liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of any soil, except cohesionless sand or other nonplastic soil, increases from a very dry state, the material changes from a solid to semisolid or plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a solid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Genesis and Morphology of the Soils

This section describes the outstanding morphological characteristics of the soils of Morton County. The first part discusses the factors of soil formation, and the second, the classification of the soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of a soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the material.

Climate and vegetation are active factors of soil genesis. They act on the parent material and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation upon soil formation are conditioned by relief. The parent material also affects the kind of profile that can be formed and in extreme cases determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. The five factors of soil formation, as they relate to the soils of Morton County, are discussed next.

Parent material.—Morton County is a part of the southern High Plains section of the Great Plains physiographic province. Less than half of it lies in the Cimarron Bend area of southwestern Kansas. Most of the soils have developed from sediments deposited during the Pleistocene and Recent epochs. The parent materials are mainly loess, eolian sand, recent alluvium, and old alluvium of the Pleistocene or Late Pliocene epochs. Figure 12, a geological cross section through the western part of the

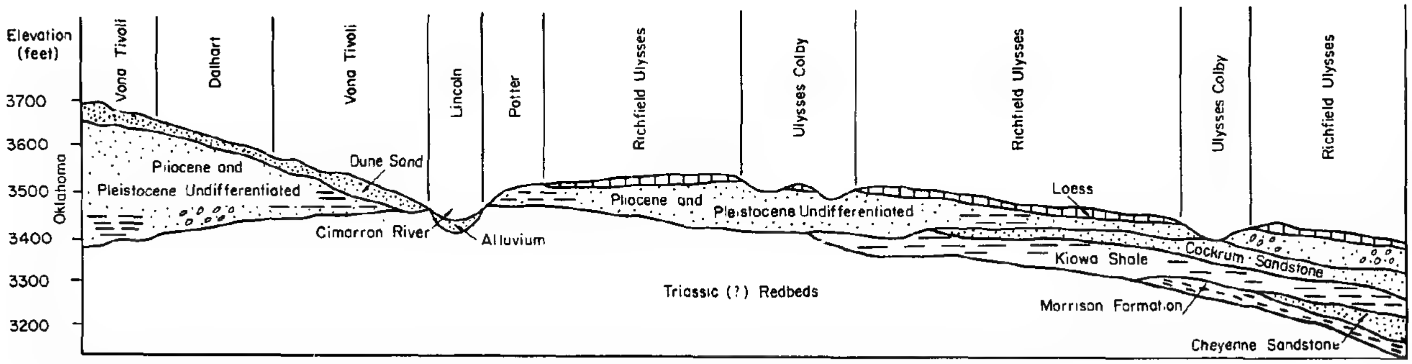

***Figure 12.*—Geological cross section through the western part of the county. (Based on plate 6 of "Geology and Ground-Water Resources of Morton Co., Kans." (*6*).)**

county, shows the broad relationship of parent material to the soil series.

Loamy windblown sediments, or loess, are the parent materials of about 52 percent of the soils in the county. This loess was deposited as a mantle over the area in the Wisconsin stage of the Pleistocene epoch, or ice age. The mantle of loess generally ranges from about 2 to 12 feet in thickness. The loess is calcareous and pale brown. It normally contains more than 50 percent silt and about 25 percent clay.

Eolian, or windblown, sands are the parent materials of about 32 percent of the soils. In most places these sands have been deposited as a mantle on the slightly older and finer textured layers of loess and outwash material. The mantle is about 2 to 30 feet thick. The deposition of these eolian sands started in the Late Pleistocene epoch and has continued intermittently until the present time. In Morton County, areas of eolian sand make up what is known as sandhills and sandy land.

The remaining 16 percent of the soils was derived from recent and old alluvial deposits. The recent alluvium is sandy and gravelly material that occurs on the flood plains of the Cimarron River. The old alluvium (Pliocene outwash) consists of stratified silty, clayey, and sandy sediments and soft limestone (Ogallala formation) that occur on the sloping areas along the Cimarron River and its tributaries.

Climate.—Morton County has a semiarid climate that is characterized by extreme temperatures in summer and winter and deficiency of moisture in all seasons. The average annual wind velocity is fairly high. Thornthwaite's PE (precipitation effectiveness) index is 26 (*3*). In this type of climate, soils develop somewhat more slowly than in areas where rainfall is abundant.

The soils reflect the effect of climate, since they contain a large amount of basic elements, and most of them are calcareous at the surface, or a few inches below it. The calcareous material occurs at about the depth to which moisture normally penetrates.

Plant and animal life.—The original vegetation consisted primarily of grasses, and grasses are still dominant. Trees occur only along the Cimarron River, mostly in thin stands. Tall grasses, such as sand bluestem, predominate on the sandy soils. Mid and short grasses predominate on the loamy soils. Over a period of many centuries, the accumulated remains of grass roots and leaves have produced the dark color of the surface layers of most of these soils.

Worms and burrowing animals affect soil development. Their activity improves aeration, mixes soil from different horizons, and aids the decomposition of plant material. Grazing by wild animals also influences soil formation both physically and chemically.

Relief.—Morton County consists of upland plains, rolling to hilly sandy land, and stream flood plains and intermediate slopes. The valleys of the Cimarron River and its tributaries interrupt the featureless plain that makes up much of the county. These valleys have gentle slopes along parts of the North Fork and abrupt slopes along most of the north side of the main channel of the river (see fig. 17).

The soils developed from loess occur on a large plain that is more or less smooth and has broad gentle swells (hills) and shallow depressions. Colby loam, 3 to 8 percent slopes, for example, shows the effect of relief. It lacks strongly expressed horizons because of high runoff and geological erosion.

The soils developed from eolian sands occur on dune-type relief. The sand dunes have been modified by time; they range from young to mature. The young dunes are steep, 20 feet or more in height, and form hilly areas on which Tivoli soils occur. The mature dunes have been subdued by wind. These low-lying dunes form undulating areas on which Vona and Dalhart soils have developed.

The soils developed from alluvium occupy the north wall and floor of the Cimarron River Valley. The relief of the north valley wall is sloping to steep; that of the valley floor is gently undulating to nearly level.

Time.—Time is necessary for the development of soils from parent materials. The time required for soil formation, however, depends on the other factors of soil formation and varies a great deal from place to place. The soils of Morton County range from very young to mature. The Tivoli soils, for example, are very young, and the Richfield soils are mature.

Classification of Soils by Higher Categories

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparisons of large areas, such as

continents. In the comprehensive system of soil classification followed in the United States (*8, 9*), the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped into three orders, whereas thousands of soil types are recognized in the lowest category. The suborder and family categories have never been fully developed and thus have been little used. Attention has been given largely to the classification of soils into soil types and series within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. Soil series, type, and phase are defined in "How Soils Are Named, Mapped, and Classified" and in the Glossary. Subdivisions of soil types into phases provide finer distinctions significant to use and management.

Classes in the highest category of the classification scheme are the zonal, intrazonal, and azonal orders. In the text of this report, the soils are referred to as zonal soils, intrazonal soils, and azonal soils.

Because of the way in which the soil orders are defined, all three can usually be found within a single county, as is true in Morton County. Two of the orders, and sometimes all three of them, may occur in a single field.

The great soil group is the next lower category beneath the order that has been widely used. Classes in that category have been used to a very great extent because they indicate a number of relationships in the soil genesis and also indicate something of the fertility status, suitability for crops or trees, and the like.

Each great soil group consists of a large number of soil series that have many internal features in common. Thus, all members of a single great soil group, if in either the zonal or intrazonal order, have the same number and kind of definitive horizons in their profiles. These definitive horizons need not be expressed to the same degree, nor do they need to be of the same thickness in all soils within one great soil group. Specific horizons must be recognizable, however, in every soil profile of a soil series representing a given great soil group.

In table 9, the 15 soil series are classified by order and great soil group, and the parent material and relief are given. Following the table, the soil series are discussed by order and great soil group. A typical profile of each series is given.

Zonal order

Soils of the zonal order have well-expressed genetic horizons. Profiles of these soils reflect primarily the effects of climate and biological factors on well-drained parent materials for a period of time adequate for full soil development. Zonal soils are sometimes called normal soils, or mature soils. The Chestnut and the Brown great soil groups are the zonal soils in the county.

CHESTNUT SOILS

The Chestnut soils have a dark-brown surface layer that grades to lighter colored material and finally to a horizon of lime accumulation. They developed under mixed tall and short grasses in a temperate to cool and subhumid to semiarid climate. There are six series in the Chestnut group in Morton County, the Dalhart, Goshen, Lofton, Manter, Richfield, and Ulysses. The Ulysses soils have some properties of the Regosol great soil group and are therefore classified as intergrades between Chestnut soils and Regosols.

TABLE 9.—*Soil series classified by soil orders and great soil groups, and parent material and relief of the soils*

Great soil groups and series	Parent material	Relief
ZONAL ORDER		
Chestnut soils:		
Dalhart	Eolian sand	Undulating upland.
Goshen	Alluvium	Nearly level flood plains that are rarely inundated.
Lofton	Loess	Shallow depressions of the upland.
Manter	Eolian sand	Gently sloping upland.
Richfield	Loess	Nearly level upland.
Ulysses [1]	Loess	Nearly level to gently sloping upland.
Brown soils:		
Vona	Eolian sand	Undulating upland.
INTRAZONAL ORDER		
Calcisols:		
Mansker	Pliocene outwash (Ogallala formation).	Sloping upland.
AZONAL ORDER		
Alluvial soils:		
Bridgeport	Loamy alluvium	Gently sloping alluvial fans.
Las Animas	Sandy alluvium	Nearly level flood plains.
Lincoln	Sandy and gravelly alluvium.	Gently undulating flood plains.
Regosols:		
Colby	Loess and old alluvium.	Gently sloping to sloping upland.
Otero	Old alluvium and eolian sand.	Gently sloping to moderately steep upland.
Tivoli	Eolian sand	Hilly upland.
Lithosols:		
Potter	Caliche or soft limestone (Pliocene outwash, Ogallala formation).	Steep, broken upland.

[1] Ulysses soils also have some properties of Regosols and are thus classified as Chestnut soils that intergrade toward Regosols.

Dalhart series.—This series consists of deep, dark, nearly level and gently sloping sandy soils of the upland. These well-drained soils have developed from sandy sediments that were deposited by wind. The vegetation was tall and mid grasses.

Dalhart soils are associated with the Vona and Richfield soils in this county. They occur on smoother slopes and contain more clay in the subsoil than the Vona soils.

They contain more sand and less clay and silt and have a less compact subsoil than the Richfield soils.

Typical profile of Dalhart fine sandy loam, 0 to 1 percent slopes (SE¼NW¼SW¼ sec. 2, T. 34 S., R. 40 W.):

A_1—0 to 8 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak, medium and fine, granular structure; soft when dry, very friable when moist; noncalcareous; gradual boundary.

B_2—8 to 22 inches, dark-brown (10YR 4/3, dry; 3/3, moist) sandy clay loam; moderate, medium and fine, granular structure; hard when dry, friable when moist; noncalcerous; gradual boundary.

C_{ca}—22 to 30 inches, pale-brown (10YR 6/3) light sandy clay loam, brown (10YR 5/3) when moist; porous massive (structureless), with some granular structure; slightly hard when dry, friable when moist; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—30 to 43 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; porous; massive (structureless); soft when dry, very friable when moist; calcareous; clear and wavy boundary.

C_u—43 to 60 inches, pale-brown (10YR 6/3) heavy loam, brown (10YR 5/3) when moist; porous; massive (structureless); slightly hard when dry, friable when moist; calcareous.

The soil types are fine sandy loam and loamy fine sand. The A_1 horizon ranges from 6 to 16 inches in thickness. The depth to calcareous material ranges from 15 to 36 inches. The depth to the loam or clay loam substratum ranges from 2 to 6 feet.

Goshen series.—This series consists of deep, moderately dark, nearly level loamy soils of the flood plains along the North Fork of the Cimarron River. These soils have developed from calcareous loamy alluvial sediments under a cover of mid and short grasses.

The Goshen soils have a thicker, darker colored surface layer and a more mature profile than the Bridgeport soils.

Profile of Goshen silt loam (NW¼NE¼ sec. 30, T. 31 S., R. 39 W.):

A_{1p}—0 to 5 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; some weak, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt boundary.

A_1—5 to 14 inches, dark grayish-brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; mostly moderate, medium and fine, granular structure but some weak, prismatic and subangular blocky structure; hard when dry, firm when moist; many worm casts; noncalcareous; gradual boundary.

AC—14 to 28 inches, brown (10YR 5/3) heavy loam, dark brown (10YR 4/3) when moist; weak to moderate, medium and fine, granular structure; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—28 to 55 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

The A_1 horizon is generally a silt loam, but there are some areas of loam. The depth to calcareous material ranges from about 10 to 18 inches.

Lofton series.—This series consists of deep, dark, poorly drained soils that occupy the shallow depressions of the upland. Water from surrounding soils drains into these depressions and in places covers them for several days until it soaks into the soil or evaporates. The parent material consists of loamy sediments.

The Lofton soils are associated with the Richfield and Dalhart soils. They have a darker colored, more clayey surface soil and subsoil than the Richfield and Dalhart soils.

Profile of Lofton clay loam (NE¼NE¼SE¼ sec. 14, T. 35 S., R. 40 W.):

A_1—0 to 8 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, medium and fine, granular structure; hard when dry, friable when moist; noncalcareous; gradual boundary.

B_2—8 to 24 inches, dark grayish-brown (10YR 4/2) light clay, very dark gray (10YR 3/1) when moist; compound moderate, medium, prismatic and moderate to strong, medium and fine, subangular blocky structure; very hard when dry, very firm when moist; noncalcareous; gradual boundary.

B_{3ca}—24 to 36 inches, brown (10YR 5/3) clay loam, dark brown (10YR 4/3) when moist; porous massive (structureless) with some subangular blocky structure; hard when dry, firm when moist; calcareous; about 3 percent of layer is small, soft concretions of calcium carbonate; gradual boundary.

C_{ca}—36 to 48 inches, pale-brown (10YR 6/3) heavy loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous; about 3 percent of layer is small, soft concretions of calcium carbonate; gradual boundary.

C—48 to 60 inches, very pale brown (10YR 7/3) loam or silt loam, pale brown (10YR 6/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

Lofton soils vary in profile characteristics from one depression to another but are somewhat similar to those in the described profile. In places the B_2 horizon has a few streaks and mottles that indicate poor drainage. The depth to the calcareous material is normally more than 20 inches. These soils occur in round or oblong, shallow depressions that generally are less than 40 acres in size.

Manter series.—The Manter series consists of deep, dark, gently sloping sandy soils of the upland. These well-drained soils have developed from eolian sandy sediments under a cover of mid and tall grasses.

The Manter soils have a darker, less sandy A_1 horizon than the Vona soils, are more sandy and less silty throughout than the Ulysses soils, and have a thicker and darker A_1 horizon than the Otero soils. They occur only in a complex with the Otero soils in this county.

Profile of Manter fine sandy loam (SE¼NE¼ sec. 35, T. 32 S., R. 43 W.):

A_{1p}—0 to 5 inches, brown (10YR 5/3) light fine sandy loam, dark brown (10YR 4/3) when moist; single grain; loose when dry, loose to very friable when moist; weakly calcareous; clear boundary.

A_1—5 to 14 inches, dark-brown (10YR 4/3, dry; 3/3, moist) heavy fine sandy loam; weak, fine and medium, granular structure; slightly hard when dry, very friable when moist; noncalcareous; gradual boundary.

C_{ca}—14 to 25 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 5/3) when moist; weakly massive (structureless) but some weak, granular structure; soft when dry, very friable when moist; calcareous; a few, small concretions of calcium carbonate; gradual boundary.

C—25 to 48 inches, light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) when moist; weakly massive (structureless); soft when dry, very friable when moist; calcareous.

The A_1 horizon is normally a fine sandy loam that ranges from 10 to 20 inches in thickness. The depth to calcareous material ranges from 12 to 26 inches. Loam or clay loam material generally occurs at a depth between 2 and 6 feet.

Richfield series.—This series consists of deep, dark, nearly level soils of the upland. These well-drained soils are the second most extensive in the country. They have developed from calcareous, loamy windblown sediments under a cover of short, mid, and tall grasses.

In this county the Richfield soils are associated with the Ulysses and Dalhart soils. They have a more clayey subsoil than the Ulysses soils and contain more clay and less sand in their subsoil than the Dalhart soils. The Richfield soils also have a higher degree of horizon development than the Dalhart and Ulysses soils.

Profile of Richfield silt loam, 0 to 1 percent slopes (NW¼SE¼ sec. 18, T. 31 S., R. 39 W.):

A_{1p}—0 to 5 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; clear boundary.

B_2—5 to 16 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; compound moderate, medium, prismatic and moderate, medium, subangular blocky structure; firm when moist, very hard when dry; noncalcareous; gradual boundary.

B_{3ca}—16 to 24 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; calcareous; a few concretions and films of calcium carbonate; gradual boundary.

C_{ca}—24 to 36 inches, pale-brown (10YR 6/3) light silty clay loam, brown (10YR 5/3) when moist; mostly porous massive (structureless) but some weak, subangular blocky structure; friable when moist, hard when dry; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—36 to 54 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

The A_1 horizon is normally less than 10 inches thick. The depth to calcareous material ranges from 14 to 24 inches.

Profile of Richfield fine sandy loam, 0 to 1 percent slopes (SE¼SE¼ sec. 19, T. 33 S., R. 39 W.):

A_{1p}—0 to 3 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; single grain (structureless); loose when both dry and moist; noncalcareous; clear boundary.

A_1—3 to 9 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak to moderate, fine and medium, granular structure; slightly hard when dry, very friable when moist; noncalcareous; gradual boundary.

B_1—9 to 13 inches, dark-brown (10YR 4/3, dry; 3/3, moist) sandy clay loam; moderate, fine and medium, granular structure; hard when dry, friable when moist; noncalcareous; gradual boundary.

B_2—13 to 22 inches, dark-brown (10YR 4/3, dry; 3/3, moist) clay loam; moderate, medium, subangular blocky structure; hard when dry, firm when moist; noncalcareous; gradual boundary.

B_{3ca}—22 to 32 inches, pale-brown (10YR 6/3) clay loam, brown (10YR 5/3) when moist; weak to moderate, medium, subangular blocky structure; becomes porous massive (structureless) in lower part of horizon; hard when dry, friable when moist; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C_{ca}—32 to 43 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous; about 2 percent of layer is small, soft concretions of calcium carbonate; gradual boundary.

C—43 to 60 inches, light yellowish-brown (10YR 6/4) heavy loam, yellowish brown (10YR 5/4) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

The soil types with a somewhat similar profile are fine sandy loam, loamy fine sand, and loam. The A_1 horizon ranges from 4 to 16 inches in thickness. The depth to calcareous material ranges from 16 to 36 inches.

Ulysses series.—This series consists of deep, well-drained, moderately dark soils of the upland. These soils are nearly level to gently sloping. They have developed from calcareous loamy sediments, mostly loess, under a cover of short and mid grasses.

Ulysses soils are associated with the Richfield and Colby soils in this county. They are less compact and contain less clay in their subsoil than the Richfield soils. They have a thicker and darker colored surface layer than the Colby soils.

Typical profile of Ulysses silt loam, 0 to 1 percent slopes (NE¼NE¼ sec. 36, T. 33 S., R. 43 W.):

A_1—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; gradual boundary.

B_2—8 to 16 inches, grayish-brown (10YR 5/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; moderate, medium, granular structure but some subangular blocky; slightly hard when dry, friable when moist; many worm casts; calcareous; gradual boundary.

C_{ca}—16 to 36 inches, pale-brown (10YR 6/3) silt loam, brown (10YR 5/3) when moist; porous massive (structureless) with some granular and subangular blocky structure in upper part; slightly hard when dry, friable when moist; calcareous; about 3 percent of layer is small, soft concretions of calcium carbonate; gradual boundary.

C—36 to 60 inches, very pale brown (10YR 7/3, moist) silt loam, pale brown (10YR 6/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

The texture of the A_1 horizon is silt loam or loam. The A_1 horizon is generally less than 10 inches thick. The B_2 horizon is weakly developed, and in some areas it is lacking and an AC horizon occurs. The texture of the B_2 or AC horizon is in places silt loam, loam, or light silty clay loam. The depth to calcareous material ranges from 0 to 15 inches.

BROWN SOILS

The Brown soils have a brown surface horizon that grades to lighter colored soil material. They have developed under short grasses, bunchgrasses, and shrubs in a temperate to cool, semiarid climate. In this county the Brown soil group includes only the Vona series.

Vona series.—This series consists of deep, light-colored, undulating sandy soils of the upland. They occur in areas of subdued dunes. These well-drained soils have developed from eolian sand under a cover of tall and mid grasses.

The Vona soils are associated with the Tivoli and Dalhart soils in this county. They are less sandy in their subsoil and occur on less sloping areas than the Tivoli soils. The Vona soils have a less clayey subsoil than the Dalhart soils.

Typical profile of Vona loamy fine sand (NW¼NW¼ sec. 26, T. 34 S., R. 40 W.):

A_1—0 to 10 inches, brown (10YR 5/3) loamy fine sand, dark brown (10YR 4/3) when moist; single grain (structureless); loose when both dry and moist; noncalcareous; clear boundary.

B_2—10 to 24 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 4/3) when moist; weak, fine and medium, granular structure; very friable when moist, slightly hard when dry; noncalcareous; gradual boundary.

B_3—24 to 36 inches light yellowish-brown (10YR 6/4) fine sandy loam, brown (10YR 5/3) when moist; weakly massive (structureless); very friable when moist, soft when dry; noncalcareous; gradual boundary.

C_{ca}—36 to 42 inches, very pale brown (10YR 7/3) loamy fine sand, pale brown (10YR 6/3) when moist; single grain (structureless); loose both when dry and when moist; calcareous; about 1 percent of layer is small, soft concretions of calcium carbonate; gradual boundary.

C—42 to 60 inches, light yellowish-brown (10YR 6/4, dry and moist) loamy fine sand; single grain (structureless); loose both when dry and when moist; calcareous.

The A_1 horizon ranges from 6 to 20 inches in thickness. The depth to calcareous material ranges from 2 to 6 feet. Loam or clay loam material generally occurs at a depth between 3 and 10 feet.

Intrazonal order

Intrazonal soils have more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal influence of climate and vegetation. In this county, the intrazonal order is represented by the Calcisol great soil group. The Calcisol group reflects the dominating influence of parent material.

CALCISOLS

Calcisols have A horizons that are variable in thickness and color, prominent deeper horizons of calcium carbonate accumulation, and calcareous parent material. These soils were formed from parent material that was high to very high in carbonates. The soils of the Mansker series are the only Calcisols in the county.

Mansker series.—This series consists of moderately deep, light-colored loamy soils of the upland. These soils occur on sloping areas just above the outcrops of the Ogallala formation. They are somewhat excessively drained. The parent material, weathered loamy material from the Ogallala formation, contains a high percentage of calcium carbonate. The Mansker soils have developed under a cover of short and mid grasses.

Mansker soils are deeper to limestone than the Potter soils. In this county they occur only in a complex with the Potter soils.

Profile of Mansker loam (SE¼NE¼ sec. 33, T. 33 S., R. 42 W.):

A_1—0 to 5 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine and medium, granular structure; slightly hard when dry, friable when moist; calcareous; gradual boundary.

AC—5 to 12 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak to moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; calcareous; gradual boundary.

C_{ca}—12 to 24 inches, very pale brown (10YR 7/3) loam, pale brown (10YR 6/3) when moist; porous massive (structureless); calcareous; a high percentage of layer is calcium carbonate.

D_r—24 inches +, soft limestone (Ogallala formation) that is generally several feet thick.

The texture of the A_1 horizon is generally loam. The depth to limestone ranges from 15 to 30 inches.

Azonal order

Soils of the azonal order are young or immature. They have few or no genetic morphological characteristics. These soils generally lack evidence of horizon differentiation, and their characteristics are similar to those of their parent materials. In places, however, they have a slight darkening of color at the surface because of an incipient accumulation of organic material. The azonal soils in the county are of the Alluvial, Regosol, and Lithosol great soil groups.

ALLUVIAL SOILS

Alluvial soils are soils developing from transported and relatively recently deposited material (alluvium) showing little or no modification by soil-forming processes. (Soils with well-developed profiles that have formed from alluvium are grouped with other soils having the same kinds of profiles but not with the Alluvial soils.) The Alluvial soils in this county are the Bridgeport, Las Animas, and Lincoln soils.

Bridgeport series.—This series consists of deep, light-colored, gently sloping soils that occupy the alluvial-colluvial fans below the steep slopes of the north wall of the Cimarron River Valley. These well-drained, immature soils are developing in local alluvial-colluvial sediments under a cover of tall, mid, and short grasses.

The Bridgeport soils somewhat resemble the Goshen soils, but they have a lighter colored and thinner surface soil and a less developed profile.

Typical profile of Bridgeport loam, 1 to 3 percent slopes (SW¼NW¼ sec. 14, T. 34 S., R. 43 W.):

A_1—0 to 8 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; gradual boundary.

AC—8 to 24 inches, pale-brown (10YR 6/3) light clay loam, brown (10YR 5/3) when moist; moderate, medium, granular structure but some subangular blocky; hard when dry, friable when moist; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—24 to 60 inches, pale-brown (10YR 6/3) heavy loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

Loam and fine sandy loam soil types are mapped in the county. The color of the A_1 horizon ranges from grayish brown to brown. The depth to calcareous material ranges from 0 to 14 inches. The texture of the subsoil is loam or clay loam.

Las Animas series.—This series consists of immaturely developed sandy soils that occupy parts of the Cimarron River flood plains. These soils are imperfectly or somewhat poorly drained. The parent material consists of sandy sediments deposited by the Cimarron River. These soils are developing under a cover of salt-tolerant, native grasses.

The Las Animas soils differ from the Lincoln soils in containing more silt and clay in the upper 2 feet.

Typical profile of Las Animas soils (NW¼SE¼ sec. 29, T. 33 S., R. 41 W.):

A_1—0 to 7 inches, dark grayish-brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, granular structure; soft when dry, very friable when moist; many worm casts; calcareous; abrupt boundary.

C_1—7 to 9 inches, pale-brown (10YR 6/3) loamy fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose both when dry and when moist; calcareous; abrupt boundary.

C_2—9 to 12 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark gray (10YR 3/1) when moist; porous massive (structureless); hard when dry, firm when moist; calcareous; abrupt boundary.

C_3—12 to 29 inches, pale-brown (10YR 6/3) fine sand or loamy fine sand, brown (10YR 5/3) when moist; single grain (structureless); loose when dry or moist; calcareous; diffuse boundary.

C_4—29 to 48 inches, very pale brown (10YR 7/4) moist fine sand with a few, medium, faint, brown mottles, pale brown (10YR 6/3.5) when moist; single grain (structureless); loose when dry or moist; calcareous.

These soils are made up largely of calcareous sandy material that is stratified with silty and clayey material. On an average the upper 12 to 24 inches is sandy loam. In most areas the water table is within 6 feet of the surface. These soils occur on nearly level flood plains that have some microrelief.

Lincoln series.—This series consists of sandy and gravelly soils that occupy the flood plains along the Cimarron River. The parent material is sandy and gravelly alluvium that has been little altered. These soils are young and unstable and in some places become a part of the river channel if they are flooded. The vegetation consists of trees, shrubs, and salt-tolerant native grasses.

The Lincoln soils differ from the Las Animas soils in containing more sand in the upper 2 feet.

Profile of Lincoln fine sandy loam (S½SE¼NW¼ sec. 4, T. 34 S., R. 42 W.):

A_1—0 to 6 inches, grayish-brown (10YR 5/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weakly massive (structureless) with a small amount of granular structure; soft when dry, very friable when moist; calcareous; abrupt boundary.

C—6 to 48 inches, very pale brown to pale brown, stratified sand; the upper 20 inches of this layer consist of fine sand; some of the strata are medium and coarse sands.

These soils are made up of stratified sand and gravel that are from 1 to 6 feet above the Cimarron River channel. The depth to the water table generally is less than 6 feet. These soils occur on nearly level to gently undulating flood plains.

REGOSOLS

Regosols consist of deep, unconsolidated rock (soft mineral deposits) in which few or no clearly expressed soil characteristics have developed. They are largely confined to recent sand dunes and to loess and glacial drift of the steeply sloping lands. The following series are in the Regosol group in Morton County: Colby, Otero, and Tivoli.

Colby series.—This series consists of deep, light-colored, gently sloping to sloping soils of the upland. These well-drained soils occur along drains and on the sloping areas adjoining the Cimarron River. They are developing in wind- and water-deposited loamy sediments under a cover of mid and short grasses.

The Colby soils have a thinner and lighter colored surface horizon than the Ulysses soils. They contain less sand throughout than the Otero soils.

Typical profile of Colby loam, 3 to 8 percent slopes (SE¼ sec. 19, T. 33 S., R. 41 W.):

A_1—0 to 4 inches, grayish-brown (10YR 5/2) loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; calcareous; gradual boundary.

AC—4 to 10 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; weak, medium and fine, granular structure; friable when moist, slightly hard when dry; calcareous; gradual boundary.

C_{ca}—10 to 22 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) when moist; porous massive (structureless) with some weak, granular structure; friable when moist, slightly hard when dry; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—22 to 48 inches, very pale brown (10YR 7/3) loam, pale brown (10YR 6/3) when moist; porous massive (structureless); slightly hard when dry, friable when moist; calcareous.

Loam and silt loam soil types are mapped in the county. The A_1 horizon ranges from 3 to 6 inches in thickness. The color of the A_1 horizon ranges from grayish brown to brown.

Otero series.—This series consists of deep, light-colored, gently sloping to moderately steep sandy soils of the upland. These well-drained soils occupy some of the gently sloping to moderately steep slopes along the Cimarron River. They are developing in calcareous sandy sediments that were deposited by water and wind. The vegetation is tall and mid grasses.

The Otero soils generally are associated with the Colby and Manter soils. Throughout their profile they contain more sand than the Colby soils. They have a lighter colored surface layer than the Manter series.

Typical profile of Otero fine sandy loam, 5 to 15 percent slopes (SE¼ sec. 14, T. 33 S., R. 41 W.):

A_1—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium and fine, granular structure; soft when dry, very friable when moist; weakly calcareous; gradual boundary.

AC—7 to 14 inches, brown (10YR 5/3) heavy fine sandy loam, dark brown (10YR 4/3) when moist; moderate, medium and fine, granular structure; slightly hard when dry, very friable when moist; calcareous; gradual boundary.

C_{ca}—14 to 24 inches, pale-brown (10YR 6/3) heavy fine sandy loam, brown (10YR 5/3) when moist; porous massive (structureless); slightly hard when dry, very friable when moist; calcareous; a few, small, soft concretions of calcium carbonate; gradual boundary.

C—24 to 48 inches, light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) when moist; weakly massive (structureless); soft when dry, very friable when moist; calcareous.

The texture of the A_1 horizon is generally fine sandy loam, and the thickness is generally less than 10 inches. The color of the C horizon ranges from pale brown (10YR) to light brown (7.5YR). A few gravel deposits occur in places.

Tivoli series.—This series consists of deep, light-colored sandy soils of the upland. These soils occur on dune-type or hilly topography in the sandy areas. They are developing in eolian sand. They are fairly well stabilized by a cover of perennial vegetation, mostly tall grasses and sand sagebrush.

The Tivoli soils contain more sand and occur on steeper areas than the associated Vona soils.

Typical profile of Tivoli fine sand (SW¼ sec. 3, T. 34 S., R. 42 W.):

A_1—0 to 4 inches, brown (10YR 5/3) fine sand, dark brown (10YR 4/3) when moist; single grain (structureless); loose when dry or moist; noncalcareous; clear boundary.

C_1—4 to 16 inches, pale-brown (10YR 6/3, dry or moist) fine sand; single grain (structureless); loose when dry or moist; noncalcareous; gradual boundary.

C_2—16 to 60 inches, very pale brown (10YR 7/4) fine sand, pale brown (10YR 6/3) when moist; single grain (structureless); loose when dry or moist; noncalcareous.

These soils are relatively uniform. The thickness of the darkened surface layer ranges from 3 to 8 inches. The texture is fine sand and loamy fine sand.

LITHOSOLS

Lithosols are soils that have little or no evidence of soil development. They consist mainly of a partly weathered mass of rock fragments or of nearly barren rock. The soils of the Potter series are the only Lithosols in Morton County.

Potter series.—This series consists of very shallow, steep soils that overlie weakly indurated caliche or limestone. The loamy parent material has weathered from the Ogallala formation. These soils generally have a sparse cover of mid and short grasses.

Potter soils are shallower and more sloping than the associated Mansker soils. They occur only in a complex with the Mansker soils in Morton County.

Typical profile of Potter loam (SE¼NE¼ sec. 33, T. 33 S., R. 42 W.):

A_1—0 to 4 inches, dark grayish-brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, medium and fine, granular structure; slightly hard when dry, friable when moist; calcareous; about 5 percent of the soil mass is composed of broken pieces of limestone or caliche; abrupt boundary.

D_r—4 inches to several feet, white, soft limestone; caprock of the Ogallala formation.

The A_1 horizon is generally less than 10 inches thick. Numerous gravel deposits occur in these soils.

Physical Geography of the County

This section includes a discussion of the Cimarron National Grassland District. Also discussed are the wildlife; climate; physiography, relief, and drainage; and water supply of the county.

Cimarron National Grassland District[7]

The Cimarron National Grassland District of the San Isabel National Forest was started in 1936 on land purchased with emergency funds of the Agricultural Adjustment Administration. From that time until 1938, about 40,000 acres along the Cimarron River were purchased.

In 1938 the Bureau of Agricultural Economics took over the area and bought enough additional acreage to make a total of 107,000 acres (fig. 13). In 1939 the area

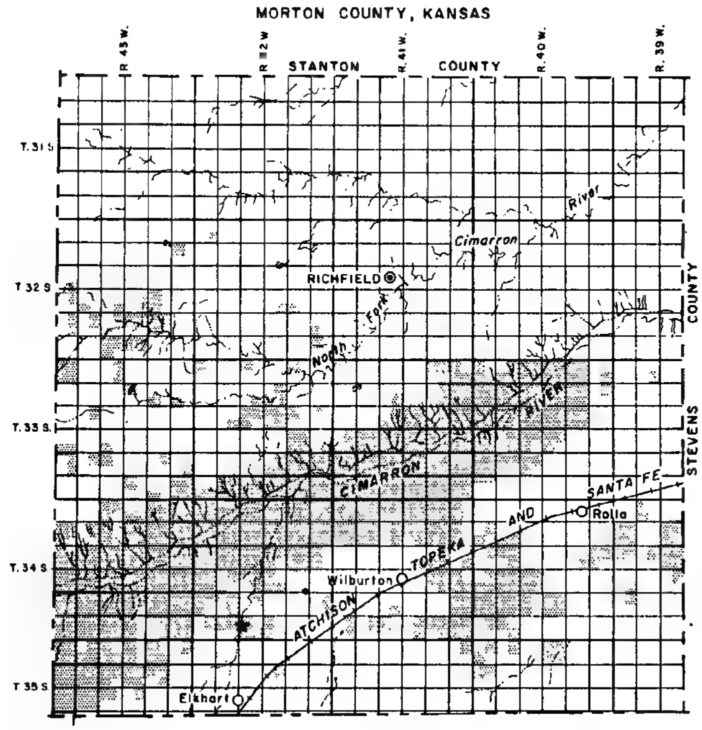

Figure 13.—**Areas of Morton County in the Cimarron National Grassland District are shown in black; project headquarters are shown by star.**

was placed under the administrative control of the Soil Conservation Service, and an active development program was started. A program of reseeding of grasses was started in the spring of 1939 and has continued to the present.

In 1954 the District was transferred from the Soil Conservation Service to the Forest Service. It was set up in July 1960 as a permanently owned Government area to be used for grazing, recreation, and wildlife. This area was thus made available to as many people as possible.

Forage is the principal resource, but the production of forage for grazing is secondary to soil stabilization. The most benefit can be derived from the area by restoring and maintaining permanent vegetation for adequate control of soil erosion. This is being accomplished mainly by reseeding, balancing the number of livestock with the available forage, and use of other range-improving practices.

The Cimarron National Grassland District is cooperating with wildlife managing agencies by providing the best habitat for game birds and animals and by regulating rodent and predatory populations. There are limited resources for fishing and big-game hunting, but game birds are plentiful. Several series of waterfowl ponds were constructed along the Cimarron River by the State Fish and Game Department. These ponds may be used for fishing later on. The use of the area by sportsmen is increasing. Among the plans for wildlife management are those designed to increase the number of game by improving their food and cover.

In 1959 a total of 4,620 recreational visits were made to the area—3,000 to developed picnic sites, and 1,620 to other sites. Of the 1,620 visits, 1,000 were for hunting,

[7] By G. ATWOOD, U.S. Forest Service, Elkhart, Kans.

500 for general enjoyment and sightseeing, 100 for fishing, and 20 for scientific studies and pursuit of hobbies.

Wildlife

The ringneck pheasant, the most important kind of wildlife, provides good hunting throughout the county. If nesting cover is provided, pheasants will remain relatively abundant.

The county has a few quail, both bobwhite and blue. The number of quail can be increased by providing cover for nesting and by complying with game laws.

Prairie chickens were once abundant, and a few still survive in the sandhills. Many jackrabbits are found in all parts of the county. Cottontail rabbits are numerous around abandoned farmsteads and along the Cimarron River. A few prairie-dog towns occur in native pastures of mid and short grasses. Other animals, such as badgers, ground squirrels, and skunks, are found in the county. There are a few deer along the Cimarron River. Mourning doves are generally numerous during summer and early fall. A few waterfowl stop over in the county during their seasonal migration.

More information on the development and improvement of areas for wildlife can be obtained from a local representative of the Soil Conservation Service or the Kansas Forestry, Fish, and Game Commission.

Climate [8]

Morton County, at the extreme southwestern corner of Kansas, has a semiarid but invigorating, continental climate. Because it is west of the general flow of moist air from the gulf and 200 miles east of the Rocky Mountains, the barrier to moisture from the Pacific, this area has scant and haphazard annual precipitation.

[8] By A. D. Robb, State climatologist, U.S. Weather Bureau, Topeka, Kans.

The relatively dry air and many hours of sunshine cause a large daily range in temperature. The open and unobstructed plains permit the invasion of cold, northern air and favor wide ranges in seasonal and annual temperatures. Periods of greater precipitation and cooler weather, lasting for several years, contrast with intervening periods of little rainfall and excess heat.

Fall and spring often bring quick, noticeable changes in weather. In fall each succeeding cold snap is a little more severe, and the sunshine of Indian summer gives way to low clouds and light, slow-falling rain or snow. In spring the cold spells wane, and showers increase until in summer they become intense thunderstorms accompanied by severe winds, lightning, and hail.

Climatic data in this section were based on weather records from the following stations in the county for the specified periods:

Station	*Temperature*	*Precipitation*
Elkhart	July 1925–Mar. 1935 May 1937–Dec. 1960	June 1918–Dec. 1960
Richfield	Jan. 1893–Nov. 1905 Aug. 1911–Nov. 1941	Mar. 1891–Oct. 1905 May 1911–Dec. 1960
Richfield, 10 miles southwest.	[1]	Jan. 1941–Dec. 1960
Elkhart, 3 miles north.	[1]	Jan. 1941–Dec. 1960
Wilburton	[1]	Jan. 1941–Oct. 1948

[1] No records available.

Morton County is not subject to so great extremes of summer and winter temperatures as are some other parts of the State. Figure 14 shows the temperature means and extremes, and the possible periods of 100° F., 32°, and 0° temperatures, based on records of the U.S. Weather Bureau at Elkhart, Kans. The range in monthly mean temperatures was from 84.4° in July 1934 to 21.0° in January 1930. Generally, severely cold weather is rare and of short duration. The coldest 2-month period was January-February 1929, when means were 30.8° and 28.0°, respectively.

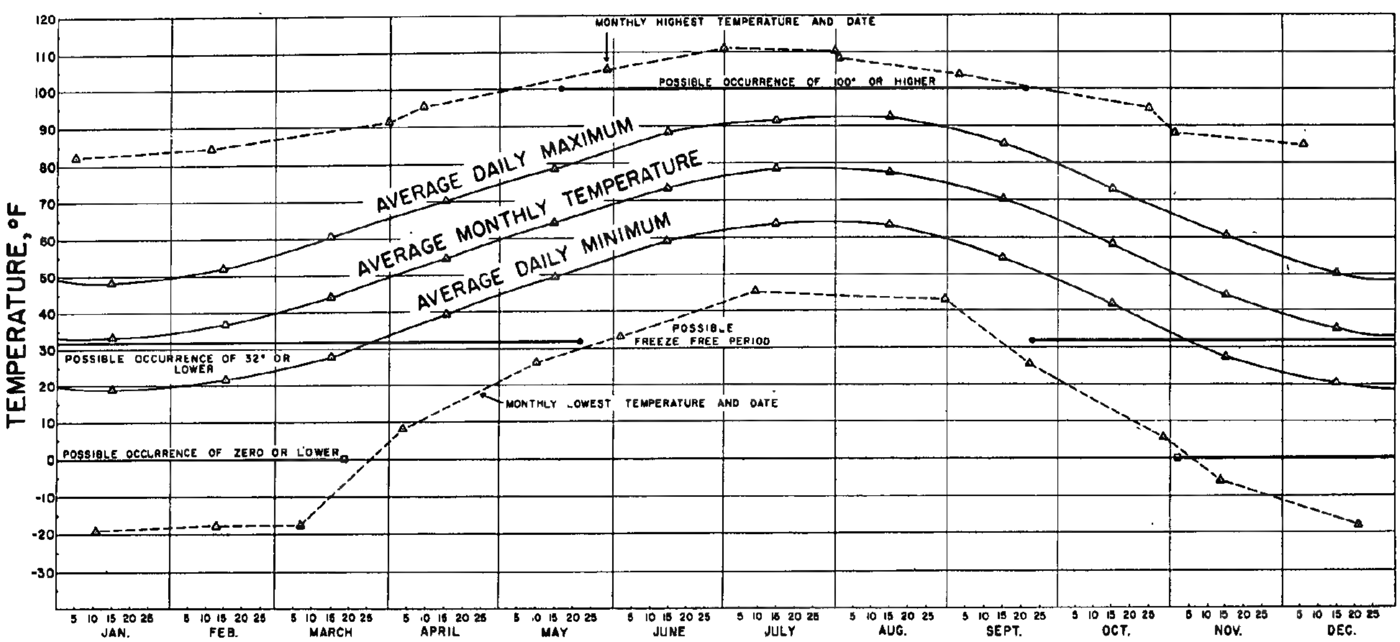

Figure 14.—**Temperature means and extremes, Elkart, Kans.**

TABLE 10.—*Temperature and precipitation extremes and probabilities*

Month	Temperature				Precipitation		
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with—		Average monthly total [3]	One year in 10 will have—	
			Maximum temperature equal to or higher than [2]—	Minimum temperature equal to or lower than [2]—		Less than [3]—	More than [3]—
	° F.	° F.	° F.	° F.	Inches	Inches	Inches
January	48. 0	18. 8	66	4	0. 40	(4)	1. 00
February	52. 2	21. 9	71	10	. 66	0. 04	1. 83
March	59. 6	28. 1	77	14	. 82	. 05	2. 02
April	69. 9	38. 9	87	27	1. 53	. 23	3. 20
May	78. 1	48. 9	92	38	2. 27	. 56	4. 90
June	87. 8	58. 5	101	49	2. 14	. 58	4. 45
July	91. 2	62. 5	102	59	2. 66	. 67	5. 28
August	92. 0	62. 5	103	56	2. 17	. 22	4. 41
September	84. 8	54. 1	96	44	1. 56	. 10	2. 96
October	73. 3	41. 9	88	32	1. 27	. 10	3. 08
November	59. 7	27. 7	77	17	. 622	(4)	1. 83
December	49. 6	20. 8	69	8	. 67	. 02	1. 40
Year	70. 5	40. 4	[5] 104	[6] −5	16. 77	[7] 9. 39	[8] 23. 40

[1] Data in column from Elkhart, in period 1925–60.
[2] Data in column from Elkhart, in period 1934–57.
[3] Data in column from Richfield, in periods 1891–1905 and 1911–60.
[4] Trace.
[5] Average annual highest maximum.
[6] Average annual lowest minimum.
[7] Annual values less than.
[8] Annual values more than.

There are few days in any winter during which the temperature fails to rise above the freezing mark and few times that it remains below zero all day. In the coldest month on record, January 1930, there were only 12 days when the maximum temperature was below freezing; 9 of these days were consecutive. During this same month, subzero temperatures occurred on 9 nights; 5 of these were consecutive. A minimum temperature of zero, or lower, is probable almost every winter. Zero temperatures have occurred as early as November 2 (1951) and as late as March 19 (1923).

Warm weather is common much of the year because of the prevalent sunshine, but extremely hot weather is exceptional. Several years have had no 100° temperatures. In only one-third of the summers recorded, the maximum temperature has risen to 100°, or higher, in each of the 3 summer months. Only twice in the 33 years on record at Elkhart has there been a temperature of 100° in 4 successive summer months. In the exceptionally hot year of 1934, the temperature rose to 100°, or higher, in 34 days in July and August. Temperatures of 100° F. have occurred as early as May 17 (1927) and as late as September 21 (1926).

Table 10 gives the extremes and the probabilities of temperature and precipitation, based on records of the U.S. Weather Bureau at Elkhart and Richfield, Kans. The columns headed "Maximum temperature equal to or higher than" and "Minimum temperature equal to or lower than" show the probability of very high or low temperatures each month, respectively. For example, the first-named column shows that extremes of 101° to 103°, or higher, may be expected about 2 years in 10 on at least 4 days in each of the months of June, July, and August. Possibly, 12 such hot days all would occur in a single summer, but it is much more probable that some would be distributed in the other 9 summers.

The column headed "Minimum temperature equal to or lower than" shows that winter cold may reach 4°, or lower, on 4 or more days in January about 2 years in 10.

Deficient and uncertain precipitation is the main factor in crop production in the county.

At Elkhart, rainfall increases from a minimum in January to a maximum in July. In January the total precipitation is more than 1.00 inch in less than 1 year in 10, whereas in July the precipitation exceeds 1.00 inch (*4*) in 8 years in 10.

The annual precipitation and the precipitation during the growing season (March through September), based on records of the U.S. Weather Bureau at Richfield, Kans., are shown in figure 15. The annual precipitation has averaged 16.77 inches at Richfield for the period shown in the graph (1891–1960). The growing-season average (March through September) is 13.15 inches.

Two very noticeable dry periods are apparent in figure 15. In the 10-year period from 1931–40, no year or growing season received the average amount. Four of the 10 growing seasons received less than half the average. The 6 dry years of the early 1950's were not as deficient nor as prolonged as those of the 30's, because there were only 4 consecutive below-average growing seasons. Over the years, 5 periods of 3 consecutive growing seasons with above-average precipitation are shown, but there is only 1 period of 4 consecutive seasons with above-average precipitation.

A comparison of the grain sorghum yield data of the U.S. Department of Agriculture, Statistical Reporting Service, with the average summer precipitation at Richfield shows that when the precipitation was 10 inches, the

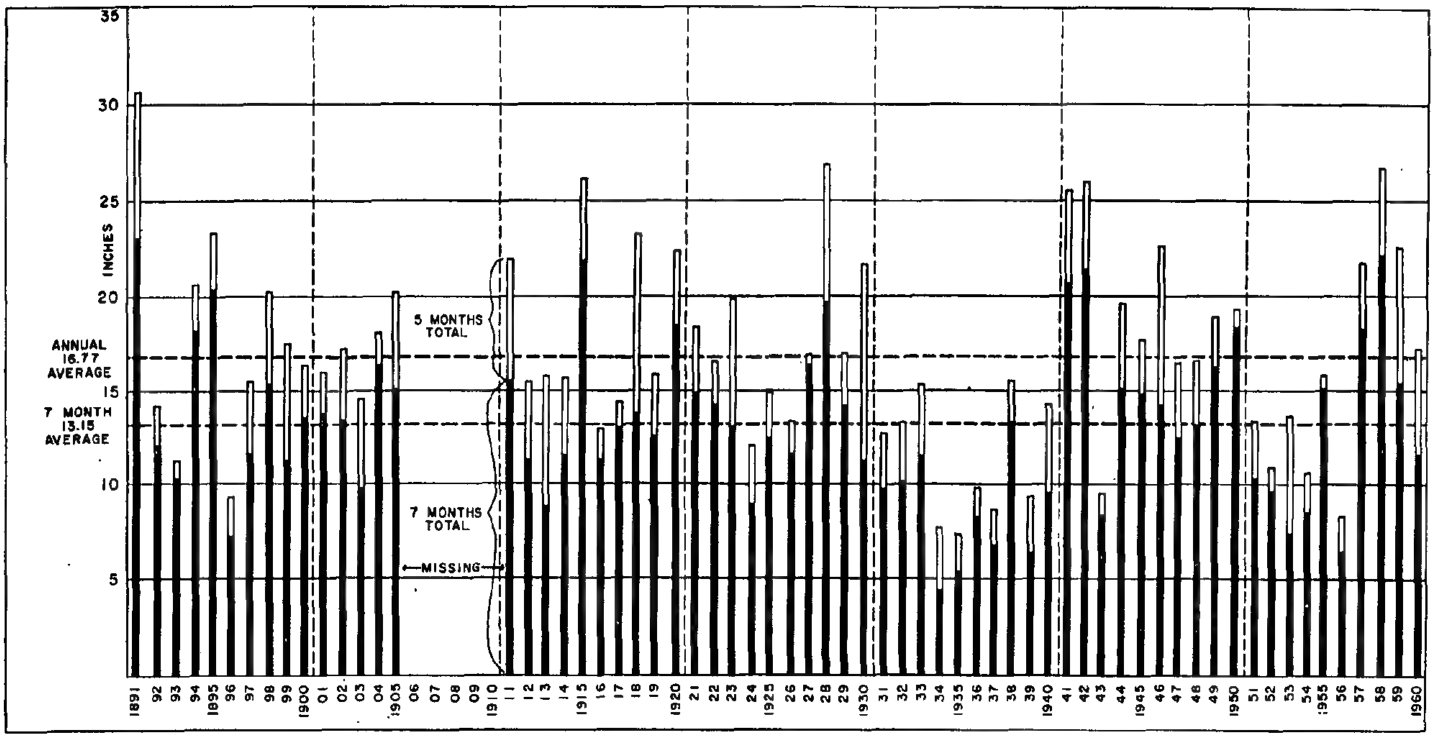

Figure 15.—**Annual and crop season precipitation at Richfield, Kans. The black, or lower part of each bar, shows the amount of precipitation during the growing season, March through September.**

yield was 7.8 bushels per acre; when it was 10 to 15 inches, the yield was 14.7 bushels per acre; and when it was 15 to 22 inches, the yield was 18.1 bushels per acre. Figure 15 shows that only 20 summers of the 65 years on record at Richfield had 15 or more inches of rain. Thus in 2 years out of 3, there is not enough rain to produce yields of grain sorghum averaging more than 18 bushels per acre. If high yields of grain sorghum are to be obtained in Morton County, rainfall should be supplemented by an improvement of plants, cultural practices, and, where possible, irrigation.

Dry periods of 30 consecutive days or more, in which there is less than 0.25 inch of rain, occur almost every year from April 1 to September 30, inclusive. Dry periods have lasted more than 50 consecutive days on several occasions—1902, 1914, and in the particularly dry periods of the 1930's and 1950's (*4*).

Figure 16 shows the probability, in percent, of receiving 0.02, 0.20, 0.60, 1.00, and 2.00 inches or more of precipitation in any 1 week in the year. The probabilities are based on records of the U.S. Weather Bureau at Elkhart, Kans.

Table 10 shows that monthly precipitation averages slightly over 2 inches from May through August, but when these monthly averages are broken down into weekly values (fig. 16), it is evident that there is a better chance of receiving rain during the latter part of May through the early days of August. There is a noticeable peak in the probability curves the last of May, especially in the smaller rainfall totals. The larger weekly amounts of 1 inch to 2 inches are most likely to occur during the middle or last of July.

Figure 16 shows that the possibility of receiving at least some rain each week, 0.02 inch (see top curve), decreases from 80 percent in week No. 14, late in May, to about 26 percent by week No. 48, the last of January.

A weekly total of 0.60 inch or more of precipitation can be expected less than half the time, even at the peak occurrence, in week No. 14 (May). Totals of 1 inch per week—a conservative estimate of water used in the summer—are most frequent the latter part of July, but then only about 1 year in 5. A total of 1 inch of rain per week is almost unknown through January and February. A total of 2 inches per week, shown by the lower curve, is likely only about 1 year in 15, even at the time of greatest possibility. The probability of other rainfall totals for any week may be obtained from the other curves.

TABLE 11.—*Frequency of intense rainfall*

Duration	Amount of rain to be expected during time given at left, once in—						
	1 year	2 years	5 years	10 years	25 years	50 years	100 years
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
30 minutes	0. 8	1. 1	1. 5	1. 8	2. 1	2. 4	2. 6
1 hour	1. 1	1. 4	1. 9	2. 3	2. 7	3. 1	3. 5
2 hours	1. 3	1. 6	2. 1	2. 6	3. 0	3. 4	3. 7
3 hours	1. 4	1. 7	2. 3	2. 7	3. 1	3. 6	4. 1
6 hours	1. 5	1. 9	2. 6	3. 0	3. 5	4. 0	4. 5
12 hours	1. 7	2. 2	2. 9	3. 5	4. 1	4. 5	5. 2
24 hours	2. 0	2. 5	3. 3	4. 0	4. 5	5. 1	5. 7

Heavy rains in 24 hours are not frequent enough to be of great concern, but they should be considered in planning roads or similar constructions. Rains of 2.00 inches or more in 24 hours have been recorded from April through October. The frequency of intense rainfall in specified periods of time is given in table 11. For example, about once each year 0.8 inch of rain may be expected to fall within 30 minutes, and once in 100 years a total of 2.6 inches is likely to fall in 30 minutes. During a 3-hour period, 1.4 inches is probable each year, 2.7 inches once in 10 years, and 4.1 inches once in a century (*5*). On September 15, 1923, the greatest 24-hour total of rainfall on the Elkhart record was 6.12 inches.

The seasonal snowfall varies greatly. One-eighth of the winters on record had less than 10 inches of snow, which was not enough to furnish 1 inch of moisture. Six of the winter seasons had 30 inches, or more. The least amount of snow, 1.5 inches, fell during 1934–35. Most of the time little benefit is derived from snow, which is blown from the fields by high winds.

The freeze-free period in Morton County averages about 180 days. The valleys and lower lying ground may have

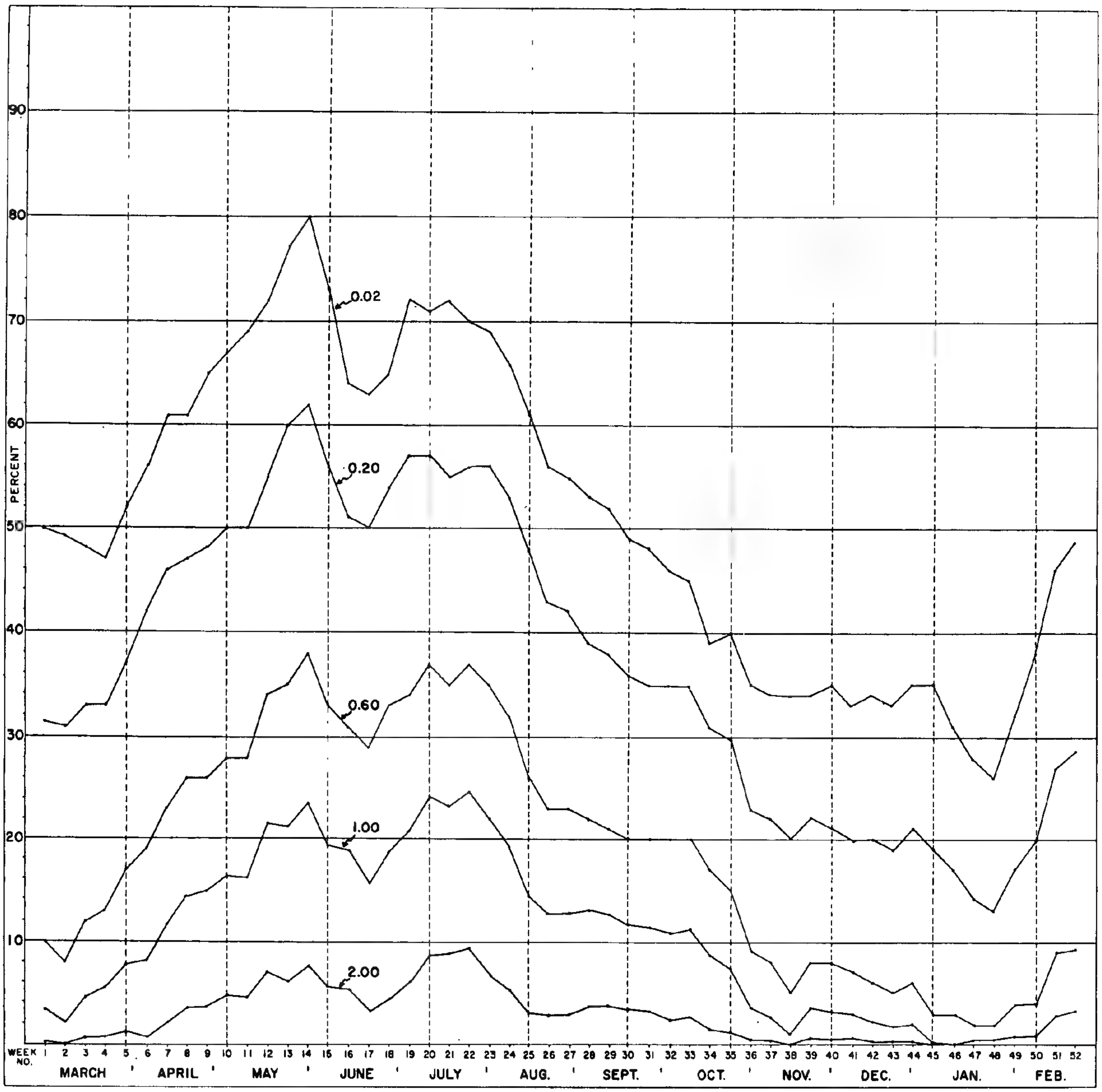

Figure 16.—**Probability, in percent, of receiving stated amount of precipitation in a 7-day period.**

TABLE 12.—*Probabilities of freezing temperatures in spring and fall*

[All data from Elkhart, Morton County, Kans.]

Probability	Dates for given probability and temperature				
	16° F., or lower	20° F., or lower	24° F., or lower	28° F., or lower	32° F., or lower
Spring:					
1 year in 10 later than	Apr. 5	Apr. 11	Apr. 17	May 1	May 9.
2 years in 10 later than	Mar. 30	Apr. 5	Apr. 12	Apr. 26	May 4.
5 years in 10 later than	Mar. 18	Mar. 26	Apr. 3	Apr. 16	Apr. 24.
Fall:					
1 year in 10 earlier than	Nov. 3	Oct. 26	Oct. 21	Oct. 13	Oct. 3.
2 years in 10 earlier than	Nov. 9	Oct. 31	Oct. 25	Oct. 19	Oct. 8.
5 years in 10 earlier than	Nov. 21	Nov. 12	Nov. 4	Oct. 27	Oct. 18.

a damaging freeze a few days later in spring or earlier in fall than the higher elevations. The crops that are commonly grown are seldom damaged by freezing, because the growing season is generally long enough to permit maturity.

The probabilities of freezing temperatures in spring and fall are given in table 12. The data in this table indicate that a 32° freeze is probable 50 percent of the time in spring as late as April 24. The probability is reduced to 10 percent by May 9. The latest recorded occurrence of a 32° freeze was on May 22, 1931. There is a 10 percent probability of a 32° freeze by October 3, and the probability increases to 50 percent by October 18 (*2*). The earliest recorded occurrence of a 32° freeze in fall was September 23, 1895. Only in the longer, colder spells is the soil frozen to a depth of more than a few inches.

Duststorms that can last several hours are a menace during long droughts. Occasional heavy snows and high winds result in blizzards, some of which are exceptionally severe.

Thunderstorms occur mostly from May through August and at times are accompanied by damaging winds. The average number of thunderstorms is approximately 50 per year. Hailstones of pea-to-marble size, driven by high winds, have preharvested a grain crop in a few minutes. On rarer occasions, hailstones the size of golf balls have killed small animals and bruised and cut the backs of cattle.

Tornadoes are another adversity, but generally they are not so long nor so frequent as in the eastern and more humid parts of Kansas.

The wind blows almost constantly, and generally from the north or south. Breezes and the low humidity make the summer heat less oppressive. The winter cold is more penetrating, however, because of the wind.

Clear days predominate in Morton County. The sun shines approximately 70 percent of the time that it is above the horizon.

Physiography, Relief, and Drainage

Morton County is a part of the southern High Plains section of the Great Plains physiographic province. About 85 percent of the county consists of upland plains and rolling to hilly sandy land, and the rest is stream flood plains and intermediate slopes. Large areas on the upland are comparatively flat and featureless. In detail, however, most parts of the flat upland are more or less uneven and consist of broad, gentle swells or hills and shallow depressions.

The sandhills have hilly and rolling topography. The sandy areas consist of sand dunes that differ in size and age. The larger dunes are 20 feet high or more. The landscape of the county is illustrated in figure 17.

The Cimarron River passes through the central part of the county. In this county it is an intermittent stream that flows only when there is a large amount of rainfall upstream. The flood plain is small and is only a few feet higher than the bottom of the river channel. Sandhills occur on the southern side of the Cimarron River, and a sloping to steep valley wall, consisting of less sandy materials, occurs on the northern side. The North Fork of the Cimarron River, also an intermittent stream, passes through the northern part of the county.

The elevation of the upland ranges from about 3,700 feet above sea level in the southwestern part of the county to 3,150 feet on the eastern county line. The lowest point in the county is in the northeastern corner on the North Fork of the Cimarron River. In general, the county slopes to the northeast and east about 15 feet per mile. The Cimarron River is more than 100 feet below the upland areas, and the North Fork of the Cimarron River is more than 50 feet below.

About 50 percent of the county is drained by the Cimarron River and its tributaries; the rest has no exterior drainage. Rain that falls on flat upland and sandhills drains into temporary ponds or small, shallow lakes, where it evaporates or percolates downward. Stream dissection in this county is in the stage known as topographic youth.

Water Supply

The entire population of this county obtains its water supply from wells. A large ground-water reservoir underlies Morton County. On the upland the depth to the water table ranges from about 30 to 225 feet. The water-bearing material—Pliocene and Pleistocene undifferentiated sediments and Cockrum sandstone formation—ranges in thickness from about 60 to 400 feet (*6*). Wells for domestic use and for livestock furnish enough

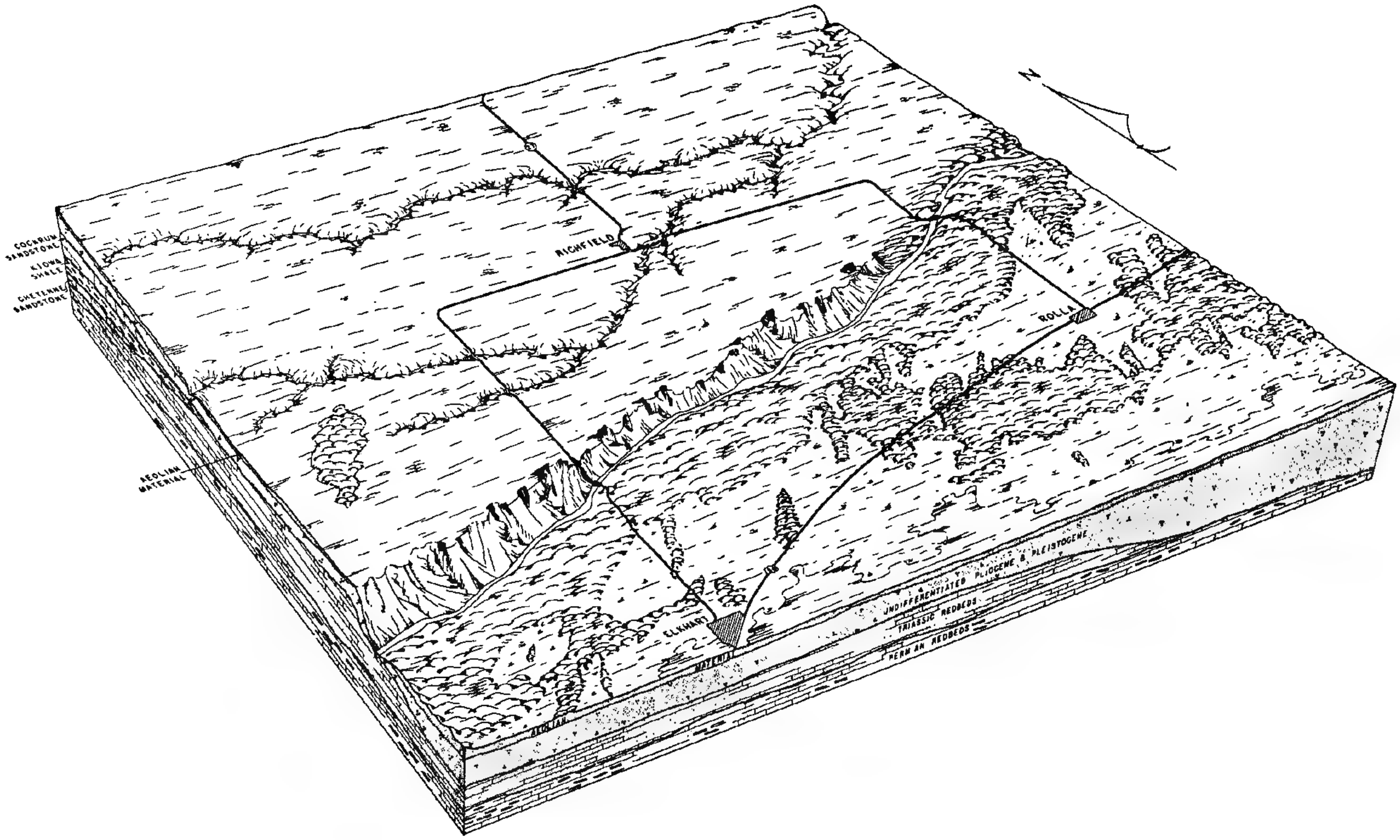

Figure 17.—**Landscape of Morton County, Kans.**

water almost any place that they are drilled in the county. Irrigation wells are not so easy to locate. Test holes have to be drilled to locate gravel or sand strata that will produce a large amount of water. In 1959 there were 48 irrigation wells in the county. The water is hard but is suitable for most uses. There are a few artesian wells, but the water from these wells is high in total salts.

Economic Geography of the County

Agricultural statistics, history and population, industries, transportation and markets, and community facilities are discussed in this section.

Agricultural Statistics

The agriculture of Morton County is based on production of wheat and grain sorghum as cash crops. This county is one of the leading producers of grain sorghum in the State.

Cattle raising was the main type of agriculture before 1920. At that time a small acreage of the better sandy soils was cultivated to produce grain and forage for cattle feed. According to the Federal census reports, the percentage in cropland increased from 35.5 of the total land area in 1930 to 65.1 of the total land area in 1959. The year 1930 was the first in which a large acreage of wheat was sown.

Farming operations in this county are on a large scale and are highly mechanized. According to the Federal census, 8,120 acres were being irrigated in 1959. Of this total, 6,366 acres were harvested cropland. Corn, alfalfa, and grasses are some of the irrigated crops grown in the county other than wheat and grain sorghum.

Only a few cattle are raised in the county; however, many are brought in for seasonal grazing.

Crops

Wheat and grain sorghum, the major crops grown, are better suited to dryland agriculture and the climate of this county than any other known crops. On the silty and loamy soils, these crops are usually grown in a crop-fallow system. During the fallow period, weeds are controlled

Table 13.—*Harvested acreage of principal crops in stated years* [1]

Crop	1930	1940	1950	1959
Winter wheat	[2] 48, 259	[2] 81, 000	[2] 116, 000	[2] 96, 000
Sorghum:				
Grain	25, 166	69, 760	81, 180	110, 000
Forage	3, 924	21, 620	13, 210	5, 000
Corn	15, 909	600	10	500
Barley	3, 805	7, 710	120	2, 800
Broomcorn	11, 262	6, 440	1, 600	680
All hay	1, 030	2, 820	580	700

[1] Based on biennial reports of the Kansas State Board of Agriculture.
[2] Planted acres.

so that moisture is conserved for use by the crop that follows. Grain sorghum is usually grown continuously on the sandy soils. A small acreage of broomcorn is also grown on the sandy soils.

Table 13 gives the acreage of the principal crops grown in Morton County in stated years.

Pasture

In 1959 there was about 139,000 acres of pasture or rangeland in Morton County, most of which was in the Cimarron National Grassland District. It occurs mainly on the sandhills and in the sandy areas of the county. If managed properly, the range will support native tall and mid grasses. About 18 percent of the pasture or rangeland is on loamy soils. These loamy soils will support native mid and short grasses.

Livestock

Cattle are the principal livestock raised in the county. The number of beef cattle in the county varies according to the local supply of feed. During fall and spring, many beef cattle are brought into the county when wheat, sorghum stubble, and native grass pasture are available. Most of the beef cattle are of good quality. The number of dairy cattle has been consistently low in recent years. Only a few farmers keep a milk cow.

Table 14 shows the number of livestock on farms and ranches of Morton County in stated years. The number of horses and mules gradually declined as tractors were improved and made available. At present most of the horses in the county are used for riding. A few farmers raise swine that are usually of good quality. Only a few sheep are raised in this county, but during fall and winter a large number may be brought in if wheat and sorghum stubble are available for grazing. A small number of poultry are kept on a few farms.

TABLE 14.—*Number of livestock on farms and ranches in stated years* [1]

Livestock	1930	1940	1950	1959
All cattle	5, 963	2, 690	5, 600	18, 000
Horses and mules	2, 442	250	230	250
Swine	789	3, 120	1, 420	400
Sheep and lambs		1, 270	9, 170	4, 180
Chickens (over 3 months old)		14, 350	13, 500	6, 000

[1] Based on biennial reports of the Kansas State Board of Agriculture.

Size, type, and tenure of farms

According to the Federal census, Morton County had a total of 288 farms in 1959. Most of these farms were large and highly mechanized. The number of farms in various size groups was as follows:

Size of farms in acres:	Number
Less than 100	5
100 to 219	17
220 to 499	55
500 to 999	82
1,000 or more acres	129

The 1959 census shows that 154 farmers resided on the farms they operated. The rest lived in towns or in other counties.

Since 1920 most of the farms have been of the cash-grain type. The 1959 Federal census shows that about 6 percent of the farms are miscellaneous and unclassified. The rest of the farms are classified by type as follows:

Type of farms:	Number
Cash grain	241
Livestock other than poultry and dairy	28
General	1

No farms in this county consist exclusively of irrigated land.

Few farmers own all the land they farm. It is common for a farmer to rent land from two or more owners. The land is usually leased on a crop-share basis; the owner gets from one-fourth to one-third of the crop. About 70 percent of the land in the county is owned by people who do not farm it. The tenure on farms, according to the 1959 Federal census, is as follows:

Type of tenure:	Number
Full owners	63
Part owners	152
All tenants	73
Total farms	288

Farm equipment and labor

All tillage and harvesting are done with mechanically powered equipment. Generally, the industrial type wheel tractor is used. Wheat and grain sorghum are harvested with large, motorized combines. Most farmers own enough equipment for tillage and planting, but some of them must hire a part or all of the machinery for harvesting. Custom operators from outside the area commonly furnish much of the labor and equipment necessary for harvesting grain crops.

The demand for labor is seasonal. The local labor supply is about adequate for planting and tillage, but transient labor is generally needed during the harvest. Only a few farmers have hired help the year round. According to the 1959 Federal census, a total of 91 farm operators had part-time jobs off their farms; of these, 35 worked 100 days or more.

History and Population

The settlement of Morton County began about 1870. Most of the early settlers were cattlemen. In 1883 this area became a part of Seward County, as at that time the western boundary of Seward County was extended to the Colorado-Kansas State line.

Morton County was organized in 1886, and the town of Richfield was made the county seat. (In a 1962 election, Elkhart was made the county seat.) The Santa Fe Trail crossed the central part of the county just north of the Cimarron River. It furnished the transportation to the county in the early days.

The population of the county in 1960 was 3,354. Richfield, the oldest town in the county, had a population of 122. Elkhart, organized after the building of the railroad across the county in 1912, had a population of 1,780. The population of Rolla was 464.

The fluctuations of the population in Morton County have been closely related to climate and crop prices. The

present population is more stable because oil and gas companies provide employment not dependent on agriculture.

Industries

Production of natural gas and oil is the main nonagricultural enterprise in the county. There are 33 gas and oil companies operating 569 oil and gas wells. About 20 percent of the working population is employed by the natural gas and oil industries.

Transportation and Markets

Except in some areas of the sandhills, there are improved roads throughout the county. Almost any part of the county is accessible by paved roads. United States Highway No. 56 and Kansas Highways No. 27 and No. 51 cross the county. A branch line of the Santa Fe Lines furnishes the only rail transportation to the county.

Most of the farm products, chiefly wheat and grain sorghum, are marketed locally. Elkhart, Rolla, Wilburton, and Richfield have facilities for grain handling and storage. The grain is shipped by railroad to the terminal elevators and markets to the east. Beef cattle are shipped to markets outside the county. Many farmers in the northern and eastern parts of the county sell their farm products in adjoining counties.

Community Facilities

There are six elementary schools and two high schools in the county. Four of the elementary schools are rural schools. The high schools are located at Elkhart and Rolla.

There are 14 churches of various denominations in the county. Elkhart has a hospital, a public library, and a public swimming pool.

Most of the farm dwellings are well kept. All have electricity, and most of them have natural gas. Rural routes provide mail service to all parts of the county.

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Glossary

Association, soil. A group of soils geographically associated in a characteristic repeating pattern.

Calcareous soil. A soil containing enough calcium carbonate to effervesce (fizz) when treated with dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter (0.000079 inch) in diameter. As a soil textural class, soil material that contains 40 percent or more of clay, less than 45 percent of sand, and less than 40 percent of silt.

Clayey soils. As used in this report, soils that contain more than 30 percent of clay.

Consistence, soil. The nature of soil material that is expressed by the resistance of the individual particles to separation (cohesion) or by the ability of a soil mass to undergo a change in shape without breaking (plasticity). The consistence varies with the moisture content. Thus, a soil aggregate or clod may be hard when dry and plastic when wet. Terms used to describe consistence are—

Very friable. When moist, soil material crushes under very gentle pressure but coheres when pressed together.

Friable. When moist, soil material crushes easily under gentle to moderate pressure between thumb and forefinger and coheres when pressed together.

Firm. When moist, soil material crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Loose. When moist or dry, soil material is noncoherent.

Soft. When dry, soil material is very weakly coherent; breaks to powder or individual grains under very slight pressure.

Slightly hard. When dry, soil material is weakly resistant to pressure; easily broken between thumb and forefinger.

Hard. When dry, soil material is moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between the thumb and forefinger.

Very hard. When dry, soil material is very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called normal field capacity, normal moisture capacity, or capillary capacity.

Flood plain. The nearly flat surface subject to overflow along stream courses.

Genesis, soil. The mode of origin of the soil, referring particularly to the processes responsible for the development of the solum (horizons A and B) from the unconsolidated parent material.

Great soil group. A broad group of soils having common internal soil characteristics.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. The relative position of the several soil horizons in a typical soil profile, and their nomenclature, are as follows—

A horizon. The surface horizon of a mineral soil having maximum biological activity, eluviation (removal of materials dissolved or suspended in water), or both.

B horizon. A soil horizon, usually beneath an A horizon, or surface soil, in which (1) clay, iron, or aluminum, with accessory organic matter, have accumulated by receiving suspended material from the A horizon above it or by clay development in place; (2) the soil has a blocky or prismatic structure; or (3) the soil has some combination of these features. In soils with distinct profiles, the B horizon is roughly equivalent to the general term "subsoil."

C horizon. The unconsolidated rock material in the lower part of the soil profile like that from which the upper horizons (or at least a part of the B horizon) have developed.

D layer. Any stratum underlying the soil profile that is unlike the material from which the soil has been formed.

Loamy soil. As used in this report, soil that contains less than 45 percent of silt, 40 to 55 percent of sand, and 10 to 27 percent of clay.

Loess. Geological deposit of relatively uniform fine material, mostly silt, presumably transported by wind. Many unlike kinds of soil in the United States have developed from loess blown out of alluvial valleys and from other deposits during periods of aridity.

Massive. Uniform masses of cohesive soil, with ill-defined and irregular cleavage; structureless.

Morphology, soil. The physical constitution of the soil expressed in the kinds of horizons, the thickness of horizons, the profile arrangement, and the texture, structure, consistence, porosity, and color of each horizon.

Normal soil. A soil having a profile in near equilibrium with its environment; developed under good but not excessive drainage from parent material of mixed mineral, physical, and chemical composition. In its characteristics it expresses the full effects of the forces of climate and living matter. Sometimes called a mature soil.

Parent material. The unconsolidated mass from which the soil profile develops.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *Very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Phase, soil. The subdivision of a soil type having variations in characteristics not significant to the classification of the soil in its natural landscape but significant to the use and management of the soil. Examples of the variations recognized by phases of the soil types are differences in slopes, stoniness, and erosion.

Profile, soil. A vertical section of the soil extending from the surface into the parent material.

Relief. The elevation or inequalities of a land surface considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter (0.002 inch) to 2.0 millimeters (0.079 inch). Usually sand grains consist chiefly of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Sandy soil. As used in this report, a soil that contains more than 55 percent of sand and less than 20 percent of clay.

Series, soil. A group of soils that have soil horizons similar in their differentiating characteristics and arrangement in the soil profile, except for the texture of the surface soil, and formed from a particular type of parent material. The soil series is an important category in detailed soil classification. Individual series are given proper names from place names near their first recorded occurrence.

Silt. Small mineral soil grains ranging from 0.05 millimeter (0.002 inch) to 0.002 millimeter (0.000079 inch) in diameter. Soils of the textural class silt contain 80 percent or more of silt and less than 12 percent of clay.

Slope. The incline of the land surface. It is usually expressed in percentage of slope, which equals the number of feet of fall per 100 feet of horizontal distance. The slope classes used in this report are as follows—

0 to 1 percent:
  Nearly level.
1 to 3 percent:
  Single slopes—gently sloping.
  Complex slopes—undulating.
3 to 5 percent:
  Single slopes—sloping.
  Complex slopes—rolling.
5 to 12 percent:
  Single slopes—strongly sloping.
  Complex slopes—hilly.

Soil. A natural body on the surface of the earth, characterized by conformable layers that result from modification of parent material by physical, chemical, and biological forces through various periods of time.

Soil separates. The individual size groups of soil particles, as sand, silt, and clay.

Soil textural class. A classification based on the relative proportion of soil separates. The principal classes, in increasing order of the content of the finer separates, are as follows: Sand, loamy sand, sandy loam, fine sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay.

Structure, soil. The natural arrangement or aggregation of primary soil particles into compound particles, or aggregates. Soil structure is classified according to grade, class, and type.

Grade. Degree of distinctness of aggregation. Grade expresses the differential between cohesion within aggregates and adhesion between aggregates. Terms: Structureless (single grain or massive), weak, moderate, and strong.

Class. Size of soil aggregates. Terms: Very fine or very thin, fine or thin, medium, coarse or thick, and very coarse or very thick.

Type. Shapes of soil aggregates. Terms: Platy, prismatic, columnar, blocky, subangular blocky, granular, and crumb.

Subsoil. That part of the soil profile commonly below plow depth and above the parent material. It may be the B horizon in soils with distinct profiles.

Substratum. Any layer lying beneath the solum, or true soil. A term applied to the parent material, or to other layers unlike the parent material that lie below the B horizon, or subsoil.

Surface soil. Technically, the A horizon; commonly, the part of the upper profile usually stirred by tillage implements.

Texture, soil. The relative proportions of the various size groups of individual soil grains.

Type, soil. A group of soils having genetic horizons similar as to differentiating characteristics, including texture and arrangement in the soil profile, and developed from a particular kind of parent material.

GUIDE TO MAPPING UNITS, CAPABILITY UNITS, AND RANGE SITES

[See table 1, p. 3, for approximate acreage and proportionate extent of the soils, and table 4, p. 18, for estimated average yields per acre of wheat and grain sorghum on given soils under two levels of management]

Map symbol	Mapping unit	Page	Capability unit: Dryland	Page	Capability unit: Irrigated	Page	Range site: Name	Page
Bo	Blown-out land	3	VIIe-1	15	(1)		Choppy Sands.	20
Bp	Bridgeport fine sandy loam, 1 to 4 percent slopes	4	IIIe-2	13	IIe-2	16	Sandy.	19
Br	Bridgeport loam, 1 to 3 percent slopes	4	IIIe-1	13	IIe-4	17	Loamy Upland.	20
Bx	Broken land	4	VIIw-1	16	(1)		----------	
Cm	Colby loam, 3 to 8 percent slopes	4	VIe-1	15	(1)		Loamy Upland.	20
Cb	Colby silt loam, 1 to 3 percent slopes	4	IVe-2	14	(1)		Loamy Upland.	20
Da	Dalhart fine sandy loam, 0 to 1 percent slopes	5	IIIe-3	14	I-2	16	Sandy.	19
Db	Dalhart fine sandy loam, 1 to 3 percent slopes	5	IIIe-2	13	IIe-2	16	Sandy.	19
Df	Dalhart loamy fine sand, 0 to 3 percent slopes	5	IVe-6	15	IIIe-5	17	Sands.	19
Go	Goshen silt loam	5	IIIc-2	14	I-1	16	Loamy Lowland.	21
Lc	Las Animas soils	5	VIs-2	15	(1)		Saline Subirrigated.	20
Lf	Lincoln soils	5	VIIw-1	16	(1)		----------	
Lo	Lofton clay loam	6	IVw-1	15	(1)		Loamy Upland.	20
Ot	Otero fine sandy loam, 5 to 15 percent slopes	6	VIe-3	15	(1)		Sandy.	19
Ox	Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded.	6	IVe-1	14	(1)		Sandy.	19
Px	Potter-Mansker complex	6	VIe-4	15	(1)		Rough Breaks-Limy Upland.	21
Ra	Richfield fine sandy loam, 0 to 1 percent slopes	7	IIIe-3	14	I-2	16	Sandy.	19
Rb	Richfield loamy fine sand, 0 to 1 percent slopes	7	IVe-6	15	IIIe-5	17	Sands.	19
Rk	Richfield loam, thick surface, 0 to 1 percent slopes	7	IIIc-1	14	I-1	16	Loamy Upland.	20
Rm	Richfield silt loam, 0 to 1 percent slopes	7	IIIc-1	14	I-1	16	Loamy Upland.	20
Tf	Tivoli fine sand	7	VIIe-1	15	(1)		Choppy Sands.	20
Tv	Tivoli-Vona loamy fine sands	8	VIe-2	15	(1)		Sands.	19
Ua	Ulysses silt loam, 0 to 1 percent slopes	8	IIIc-1	14	I-1	16	Loamy Upland.	20
Ub	Ulysses silt loam, 1 to 3 percent slopes	8	IIIe-1	13	IIe-4	17	Loamy Upland.	20
Ue	Ulysses-Colby complex, 1 to 3 percent slopes, eroded	8	IVe-2	14	(1)		Limy Upland.	20
Vo	Vona loamy fine sand	9	IVe-1	14	IVe-7	17	Sands.	19

[1] Considered unsuitable for irrigation.

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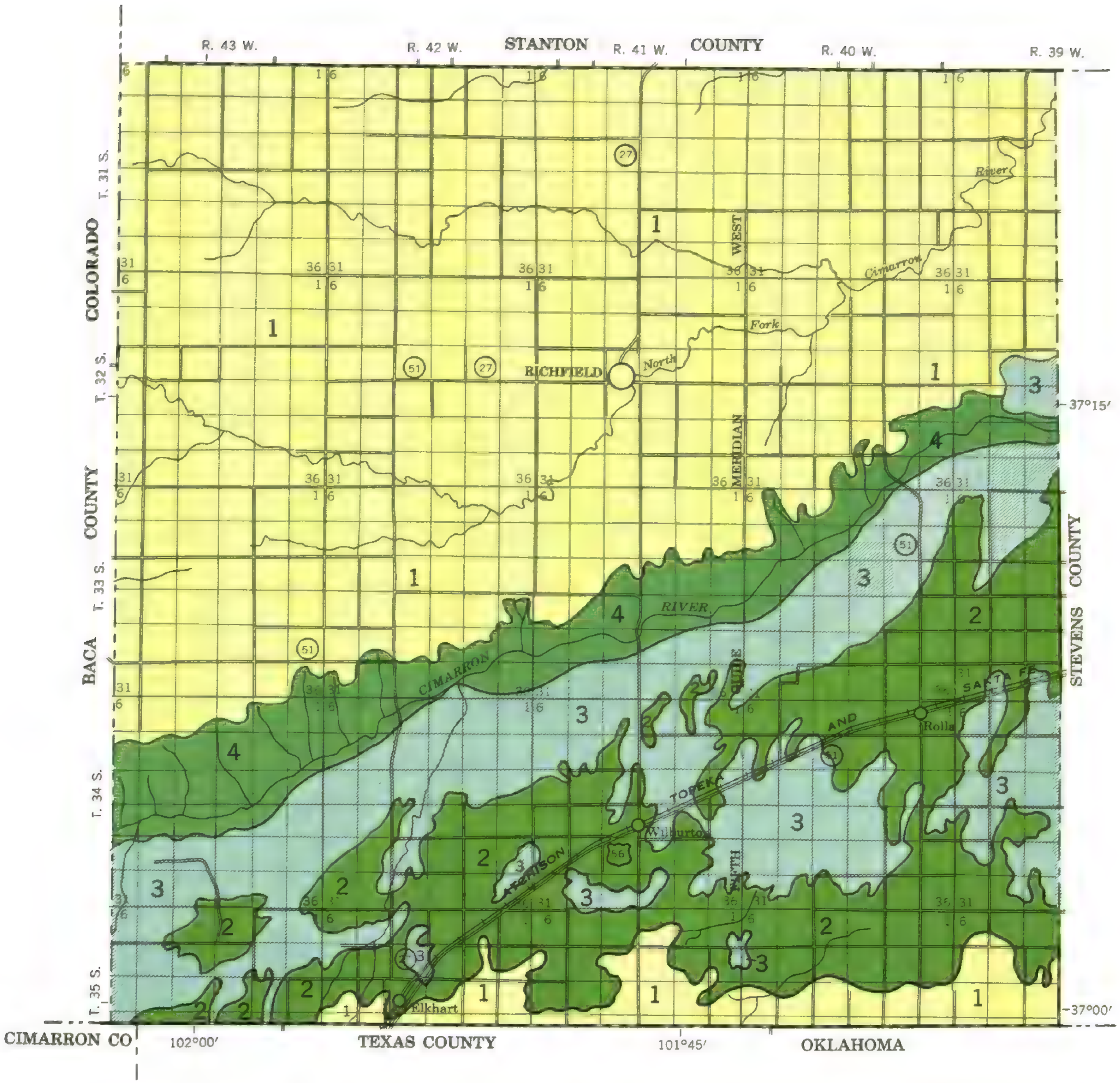
For additional information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, call either the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish, or the State Information/Hotline Numbers (http://directives.sc.egov.usda.gov/33085.wba).

All Other Inquiries

For information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices (http://directives.sc.egov.usda.gov/33086.wba).



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
KANSAS AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP
MORTON COUNTY, KANSAS

SOIL ASSOCIATIONS

1 — Richfield-Ulysses association: Loamy soils of uplands

2 — Dalhart-Richfield association: Moderately sandy land

3 — Vona-Tivoli association: Rolling sandy land

4 — Otero-Lincoln association: Soils of the Cimarron River Valley and adjacent slopes

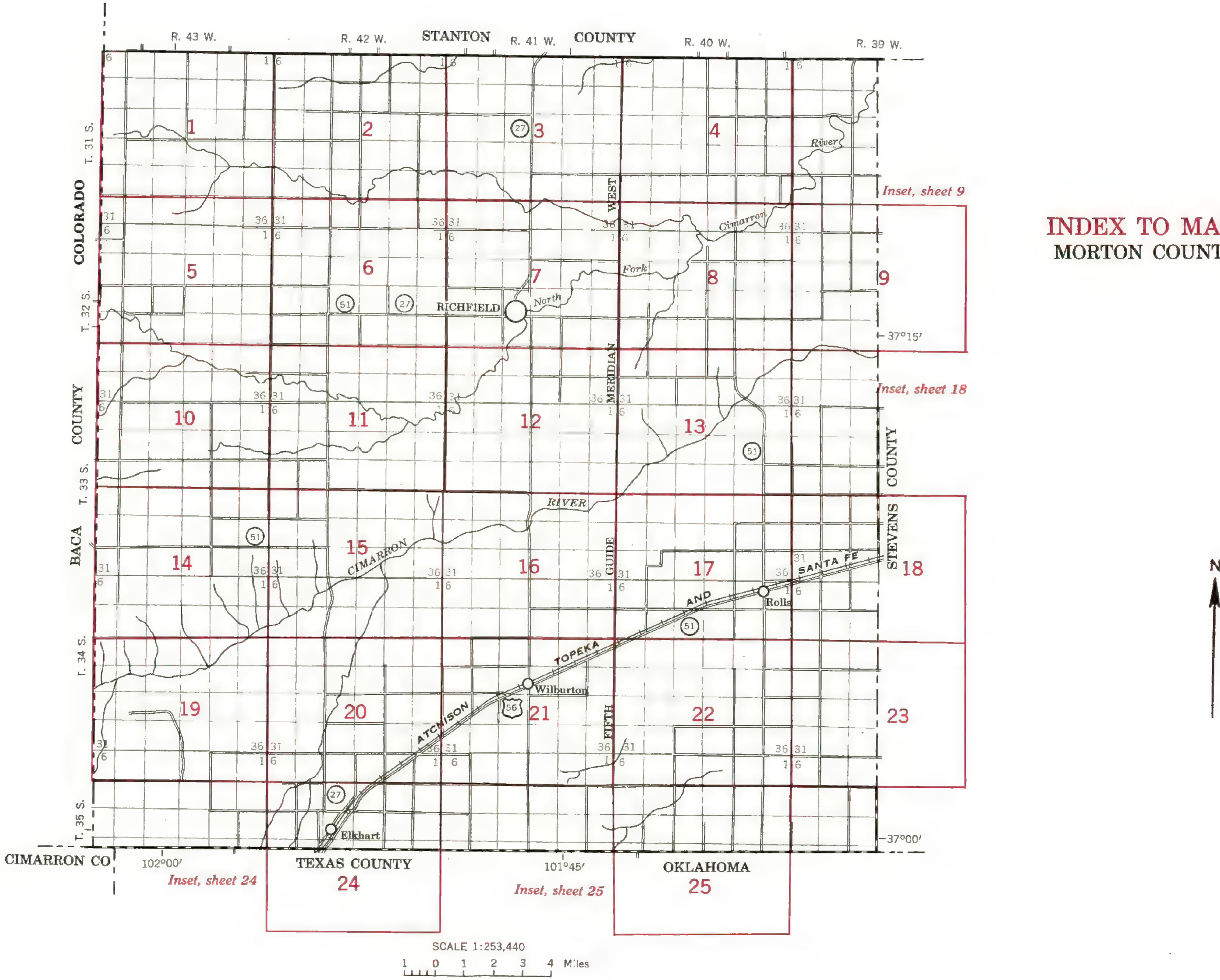
March 1963

N

SCALE 1:253,440

1 0 1 2 3 4 Miles

INDEX TO MAP SHEETS
MORTON COUNTY, KANSAS



SCALE 1:253,440

1 0 1 2 3 4 Miles

SOIL LEGEND

SYMBOL	NAME
Bo	Blown-out land
Bp	Bridgeport fine sandy loam, 1 to 4 percent slopes
Br	Bridgeport loam, 1 to 3 percent slopes
Bx	Broken land
Cb	Colby silt loam, 1 to 3 percent slopes
Cm	Colby loam, 3 to 8 percent slopes
Da	Dalhart fine sandy loam, 0 to 1 percent slopes
Db	Dalhart fine sandy loam, 1 to 3 percent slopes
Df	Dalhart loamy fine sand, 0 to 3 percent slopes
Go	Goshen silt loam
Lc	Las Animas soils
Lf	Lincoln soils
Lo	Lofton clay loam
Ot	Otero fine sandy loam, 5 to 15 percent slopes
Ox	Otero-Manter fine sandy loams, 1 to 3 percent slopes, eroded
Px	Potter-Mansker complex
Ra	Richfield fine sandy loam, 0 to 1 percent slopes
Rb	Richfield loamy fine sand, 0 to 1 percent slopes
Rk	Richfield loam, thick surface, 0 to 1 percent slopes
Rm	Richfield silt loam, 0 to 1 percent slopes
Tf	Tivoli fine sand
Tv	Tivoli-Vona loamy fine sands
Ua	Ulysses silt loam, 0 to 1 percent slopes
Ub	Ulysses silt loam, 1 to 3 percent slopes
Ue	Ulysses-Colby complex, 1 to 3 percent slopes, eroded
Vo	Vona loamy fine sand

Soil map constructed 1962 by Cartographic Division, Soil Conservation Service, USDA, from 1960 aerial photographs. Controlled mosaic based on Kansas plane coordinate system, south zone, Lambert conformal conic projection, 1927 North American datum.

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferries
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries
- Mine dump
- Pits, gravel or other

Power lines

Pipe lines

Cemeteries

Dams

Levees

Tanks

Oil wells

Windmills

BOUNDARIES

- National or state
- County
- Township, U. S.
- Section line, corner
- Reservation
- Land grant

DRAINAGE

Streams
- Perennial
- Intermittent, unclass.

Canals and ditches — CANAL — DITCH

Lakes and ponds
- Perennial
- Intermittent

Wells — flowing

Springs

Marsh

Wet spot

RELIEF

Escarpments
- Bedrock
- Other

Prominent peaks

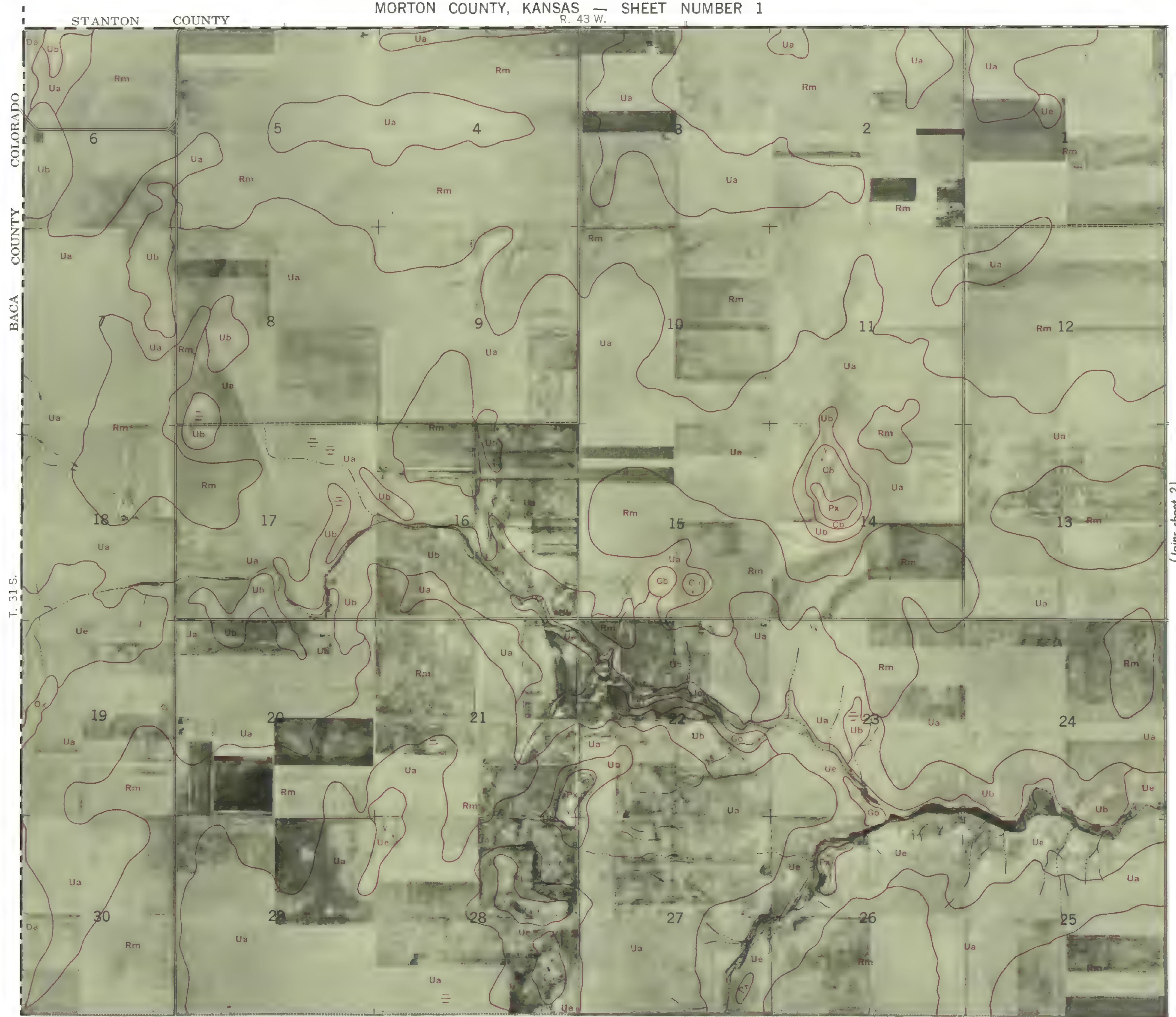
Depressions — Large — Small

SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stones
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gullies

MORTON COUNTY, KANSAS — SHEET NUMBER 1

1



0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

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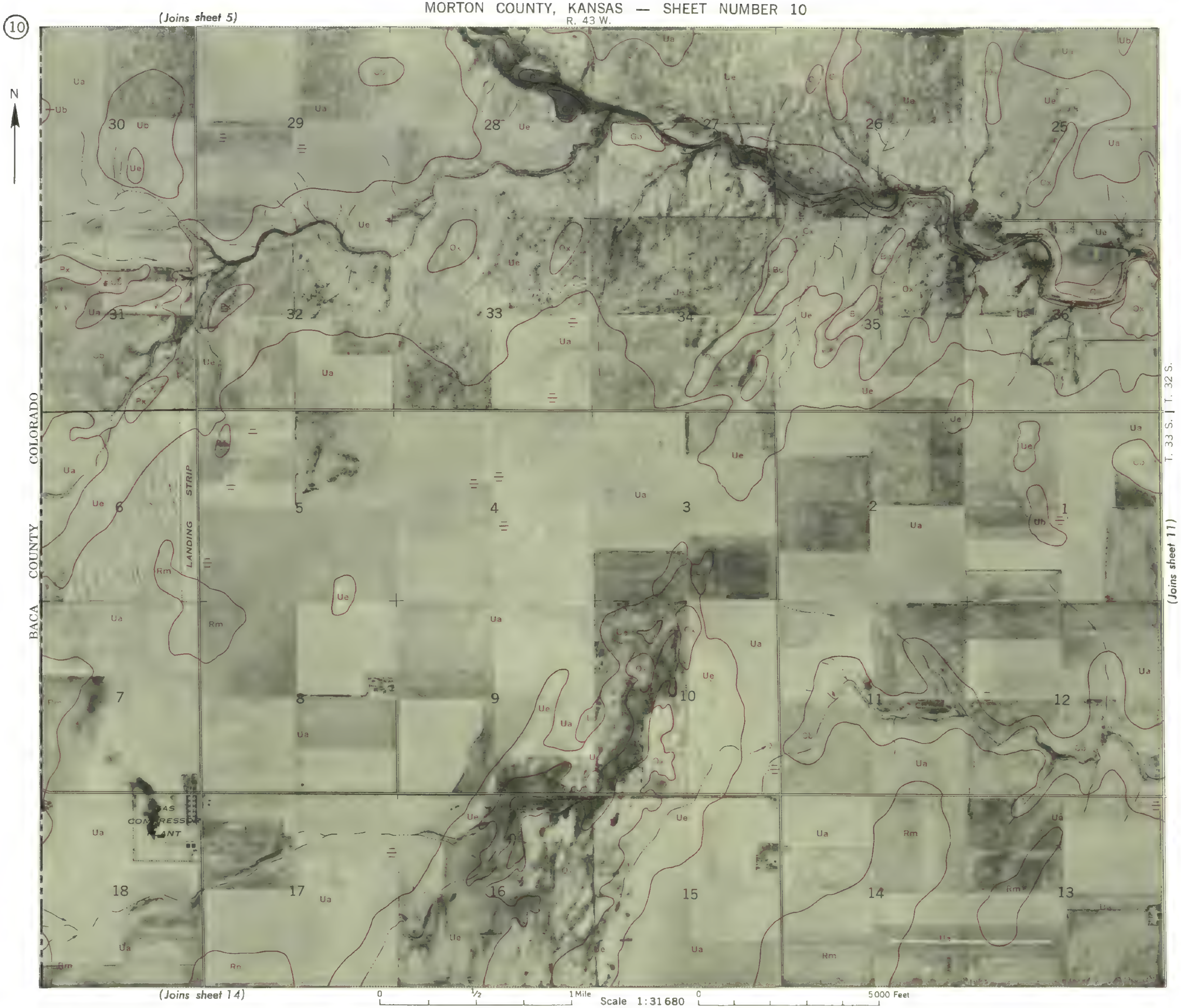
10

MORTON COUNTY, KANSAS — SHEET NUMBER 10



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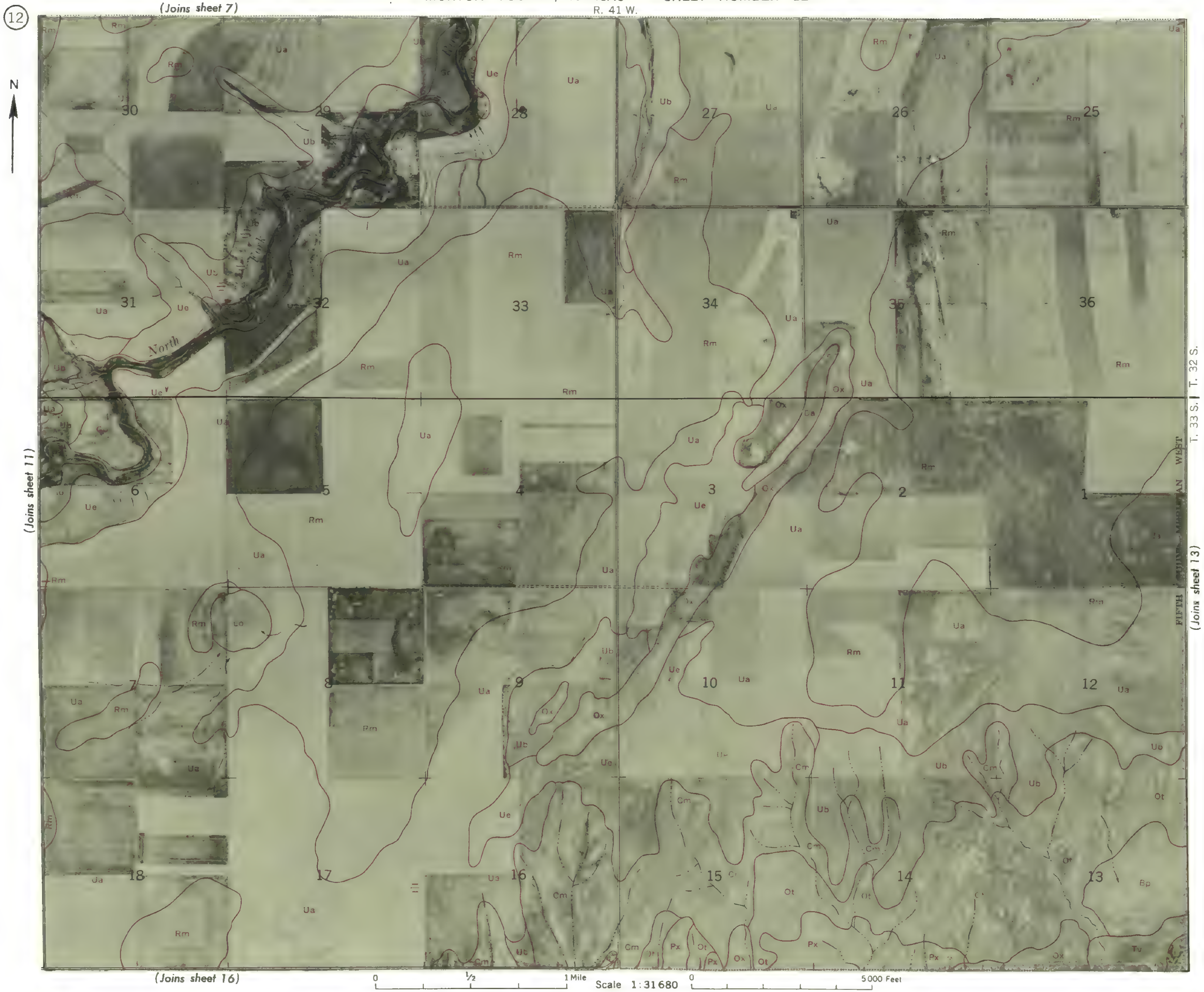
MORTON COUNTY, KANSAS — SHEET NUMBER 11

MORTON COUNTY, KANSAS — SHEET NUMBER 12



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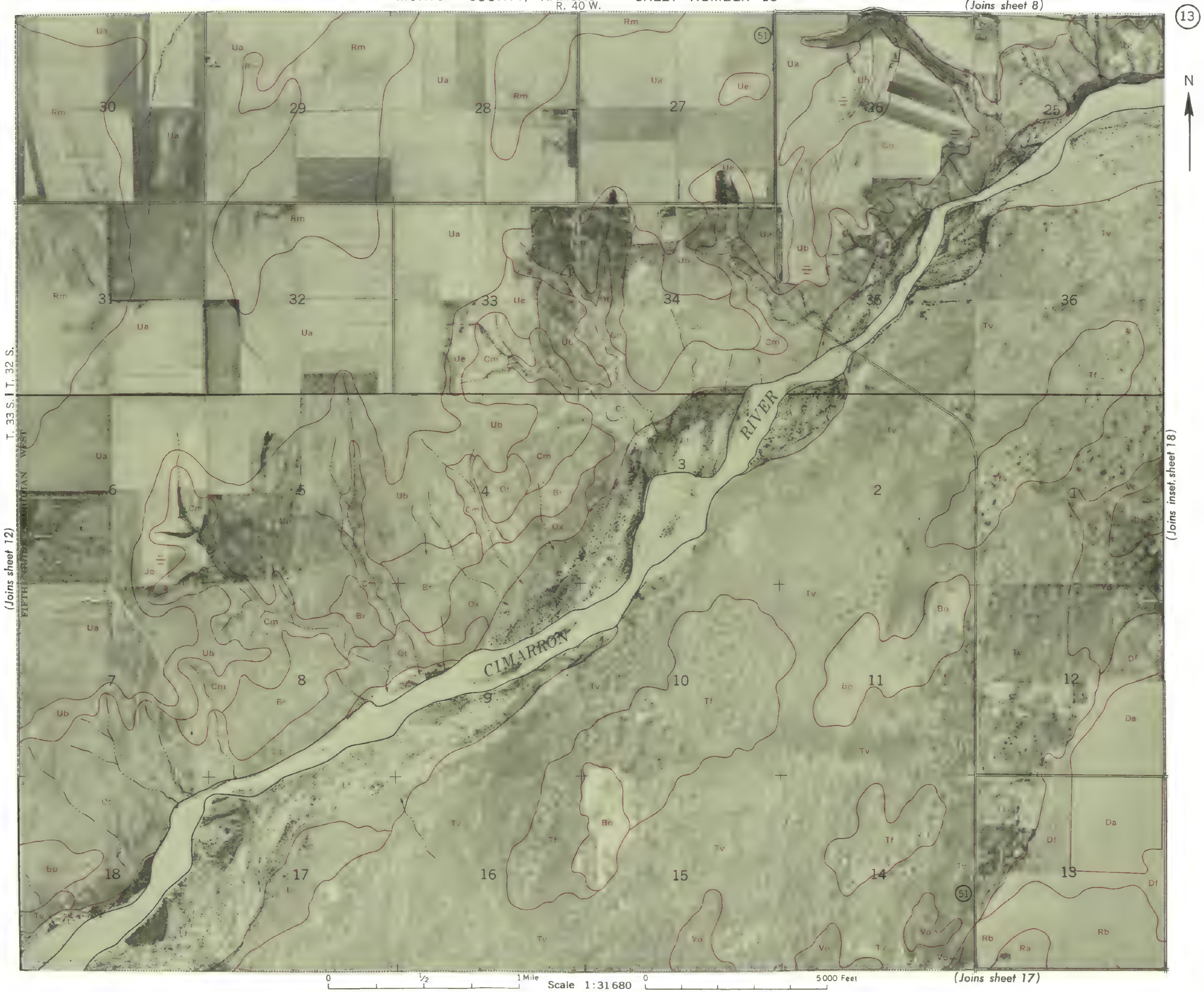

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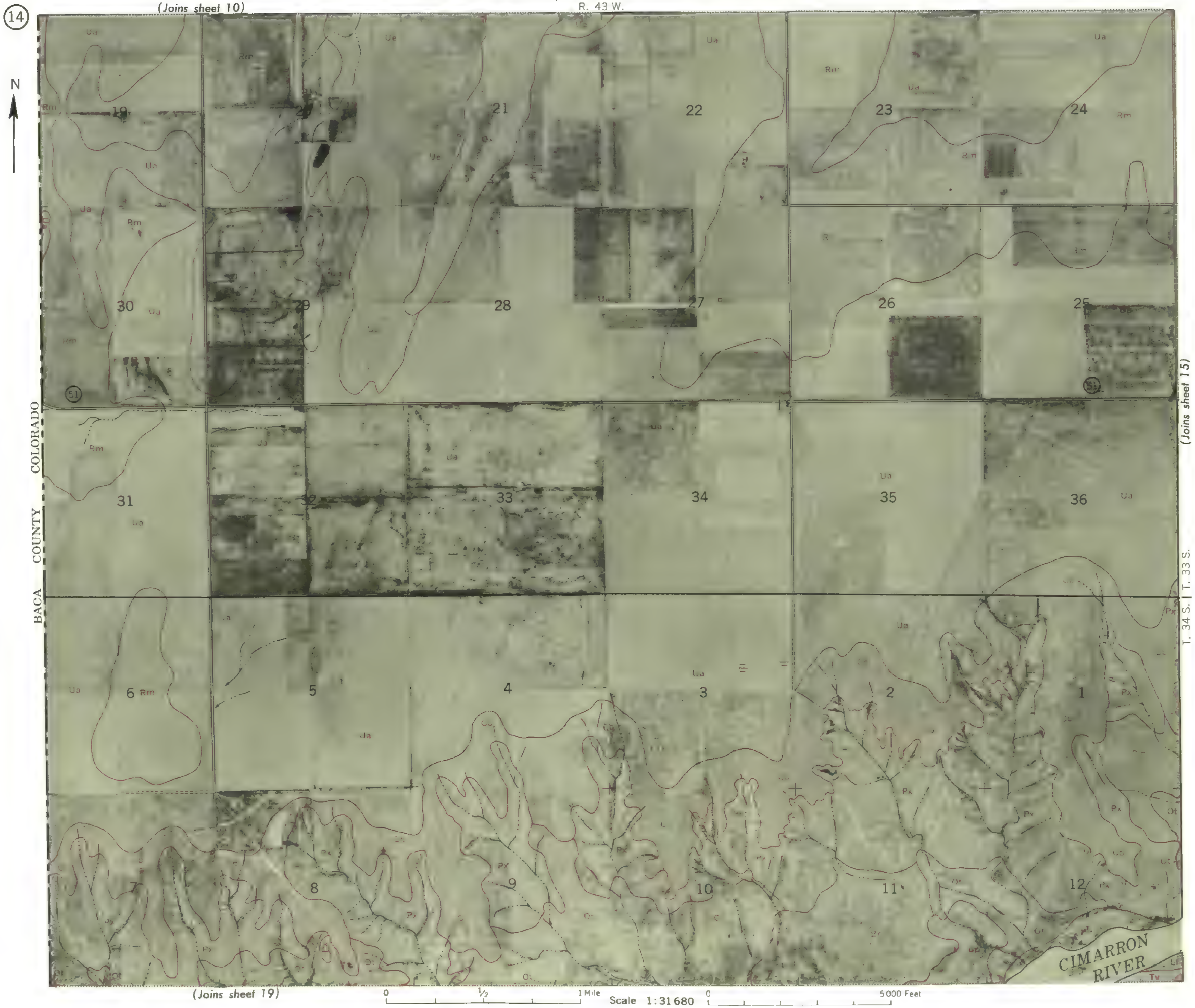
MORTON COUNTY, KANSAS — SHEET NUMBER 14



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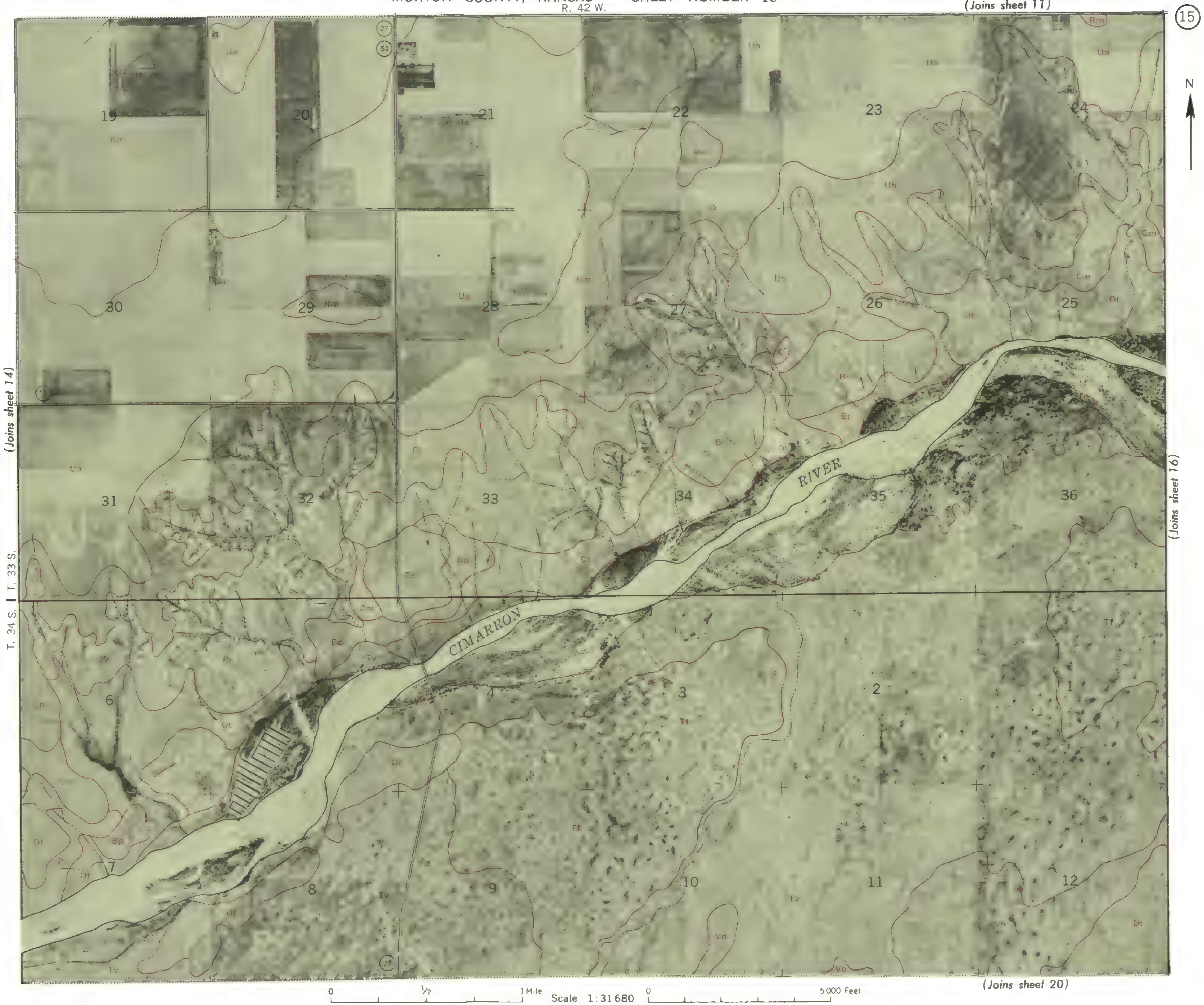

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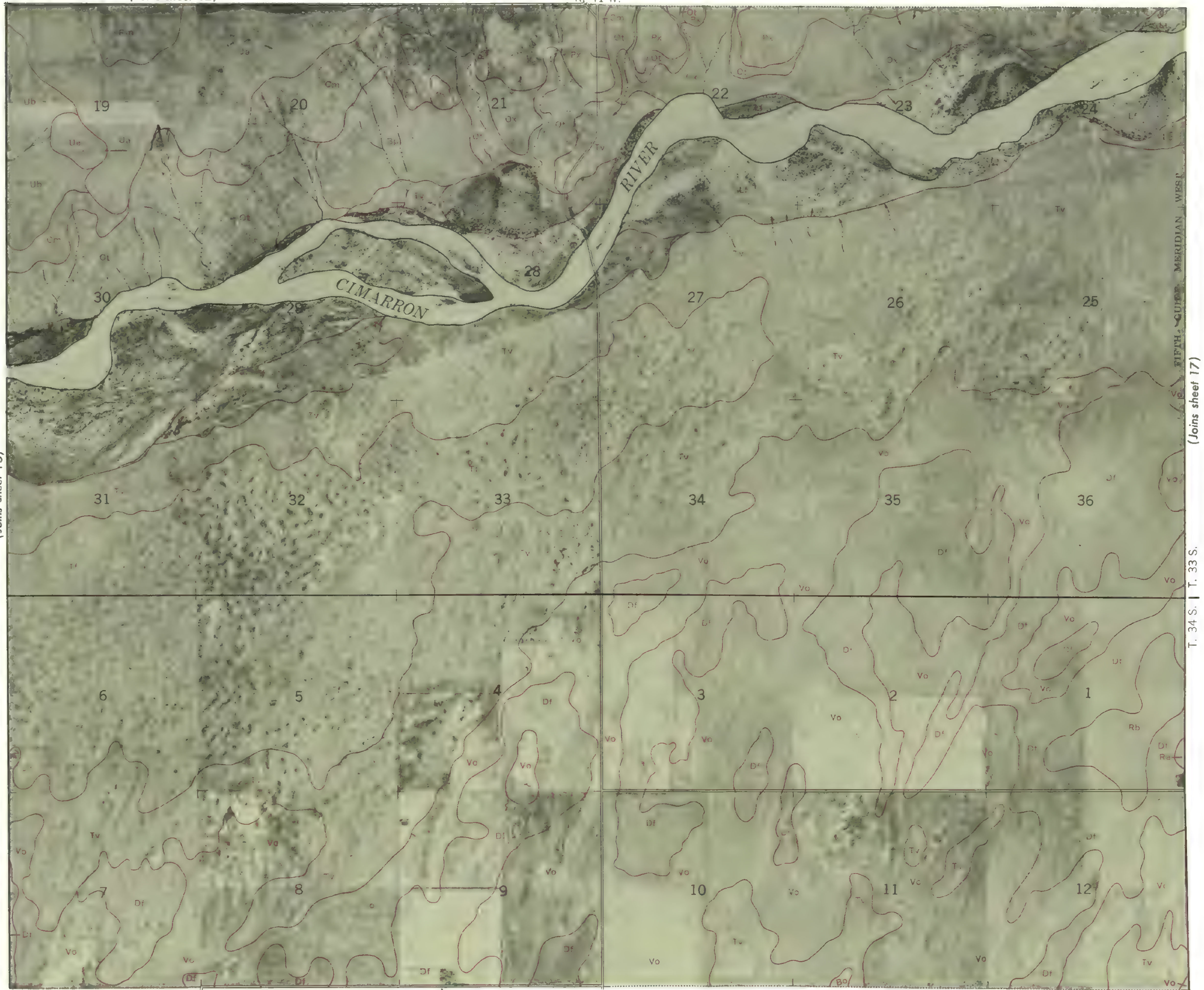
(16)

MORTON COUNTY, KANSAS — SHEET NUMBER 16

(Joins sheet 12)



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(Joins sheet 17)

(Joins sheet 21)

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

MORTON COUNTY, KANSAS — SHEET NUMBER 17

R. 40 W.

(Joins sheet 13)

17

(Joins sheet 16)

T. 33 S.

T. 34 S.

(Joins sheet 18)

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

(Joins sheet 22)

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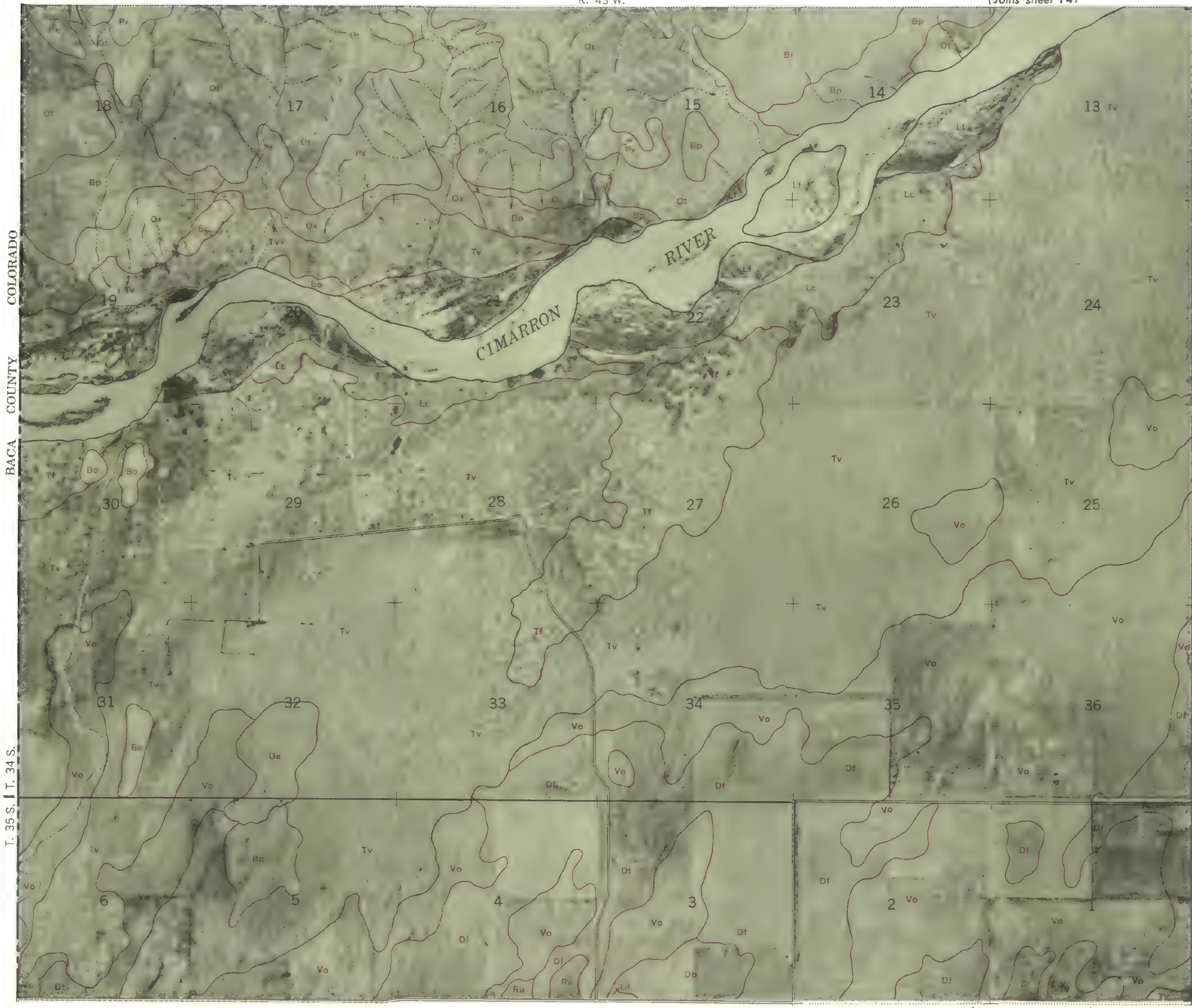
(18)

MORTON COUNTY, KANSAS — SHEET NUMBER 18

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

MORTON COUNTY, KANSAS — SHEET NUMBER 19

R. 43 W. (Joins sheet 14) 19



(Joins inset, sheet 24)

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

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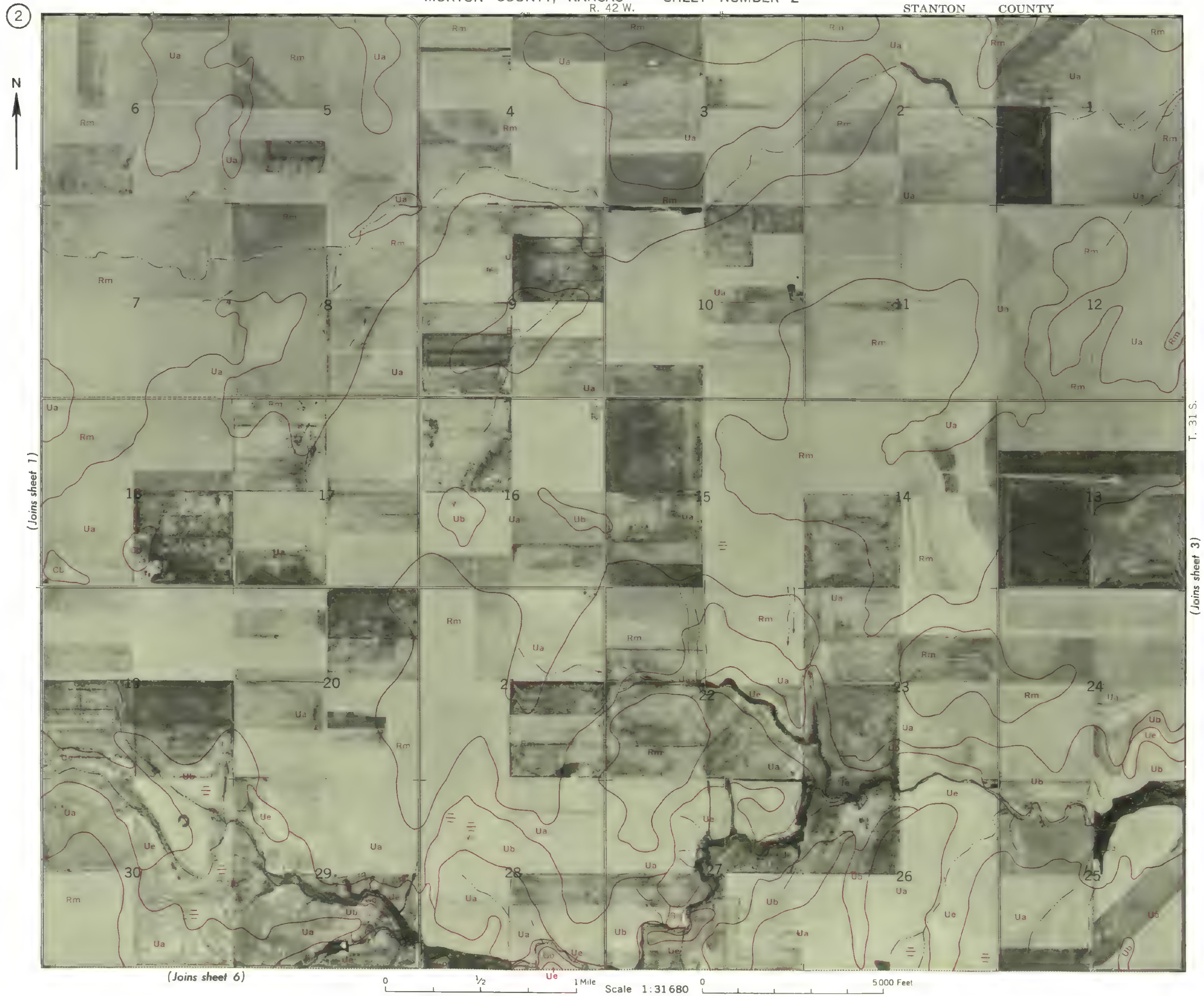

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MORTON COUNTY, KANSAS — SHEET NUMBER 21

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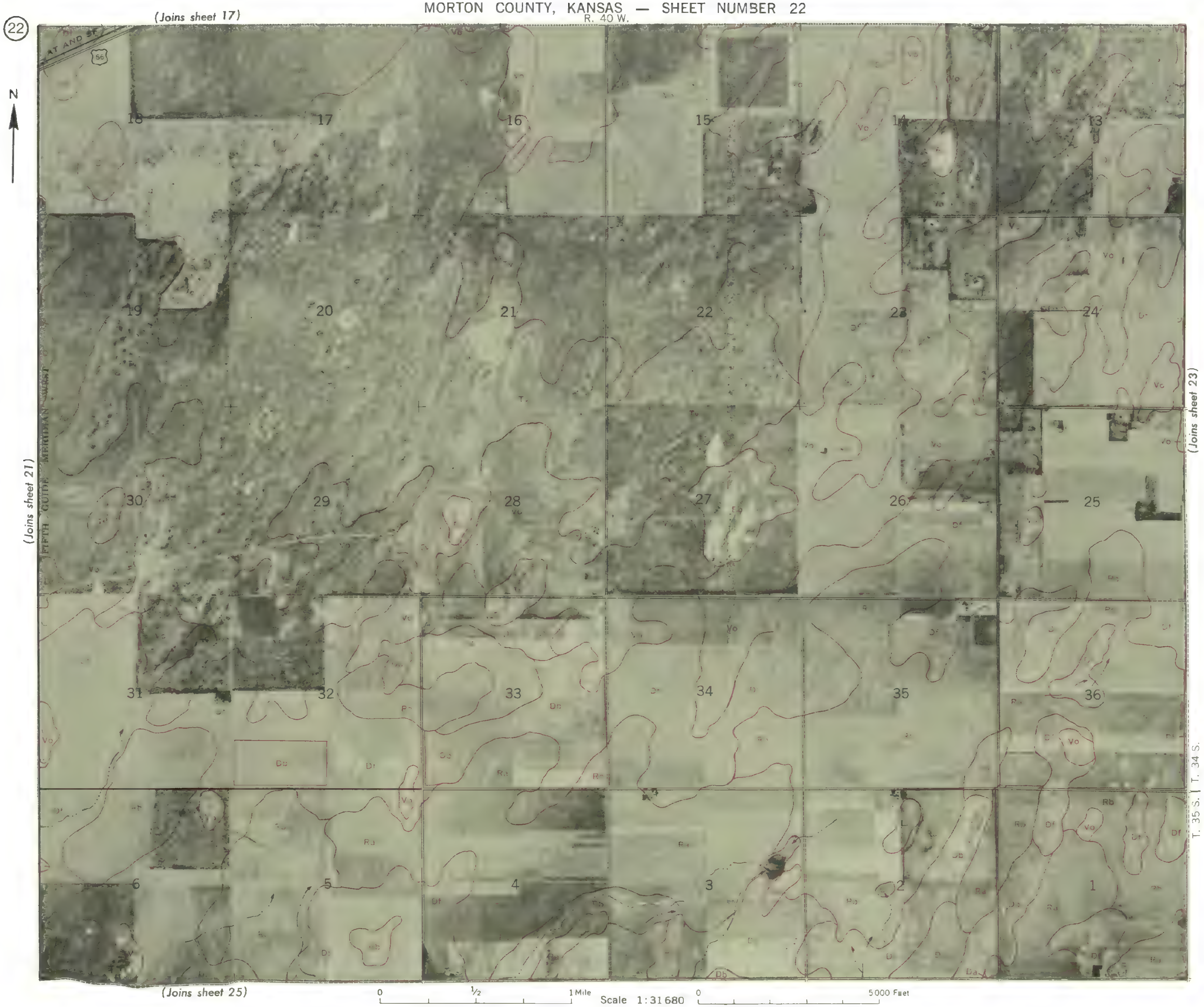
22
(Joins sheet 17)
R. 40 W.
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FIFTH GUIDE MERIDIAN WEST
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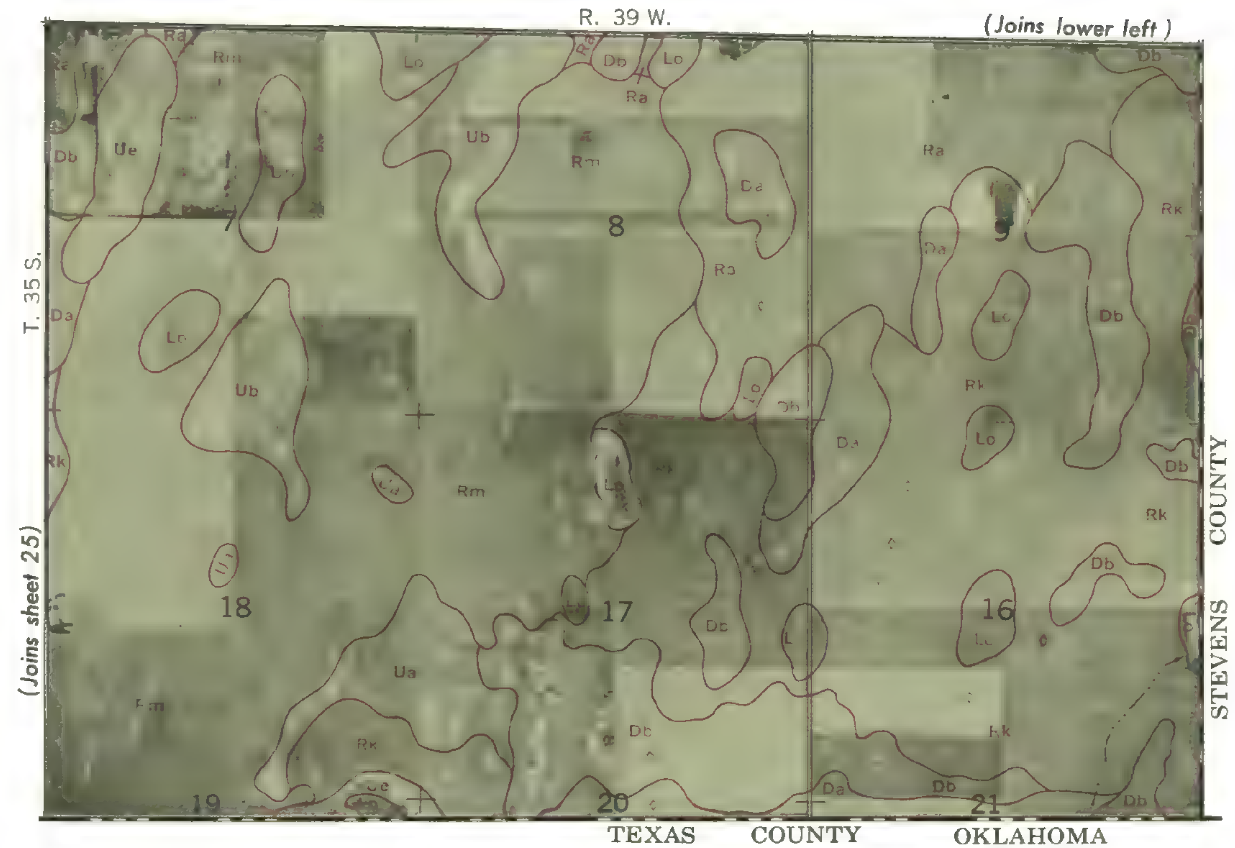

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

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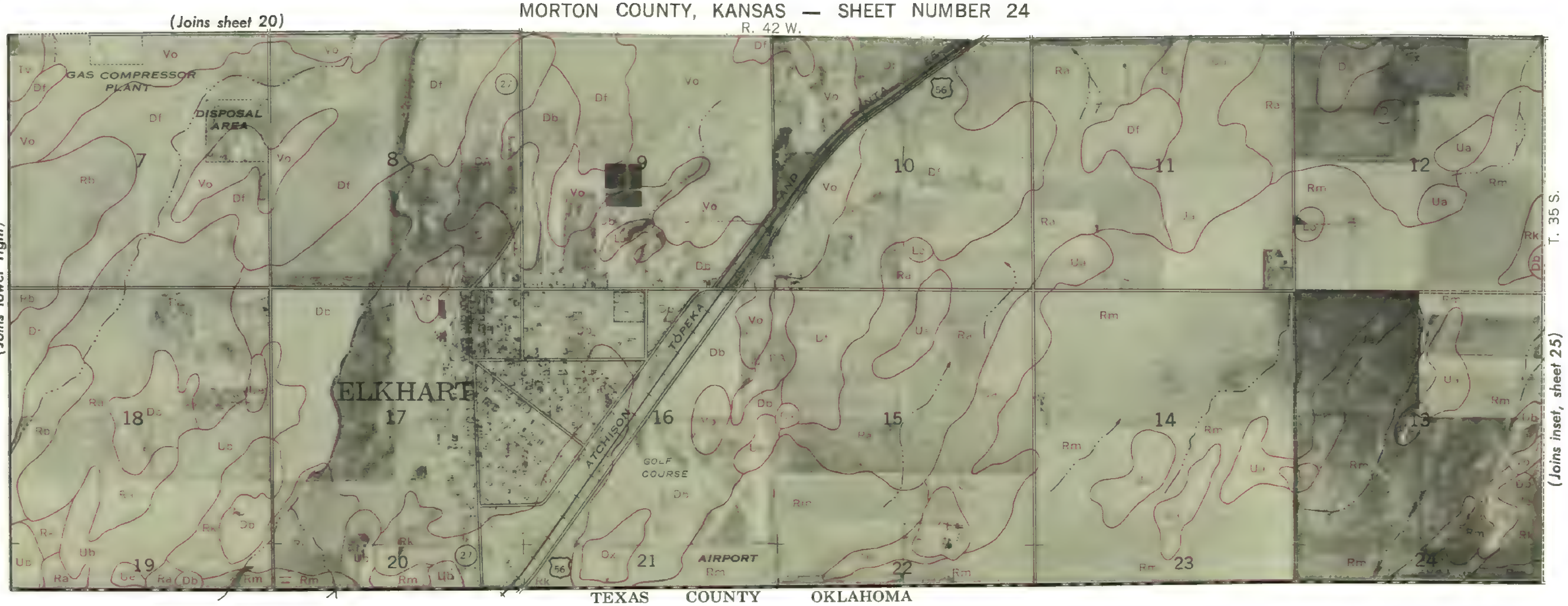
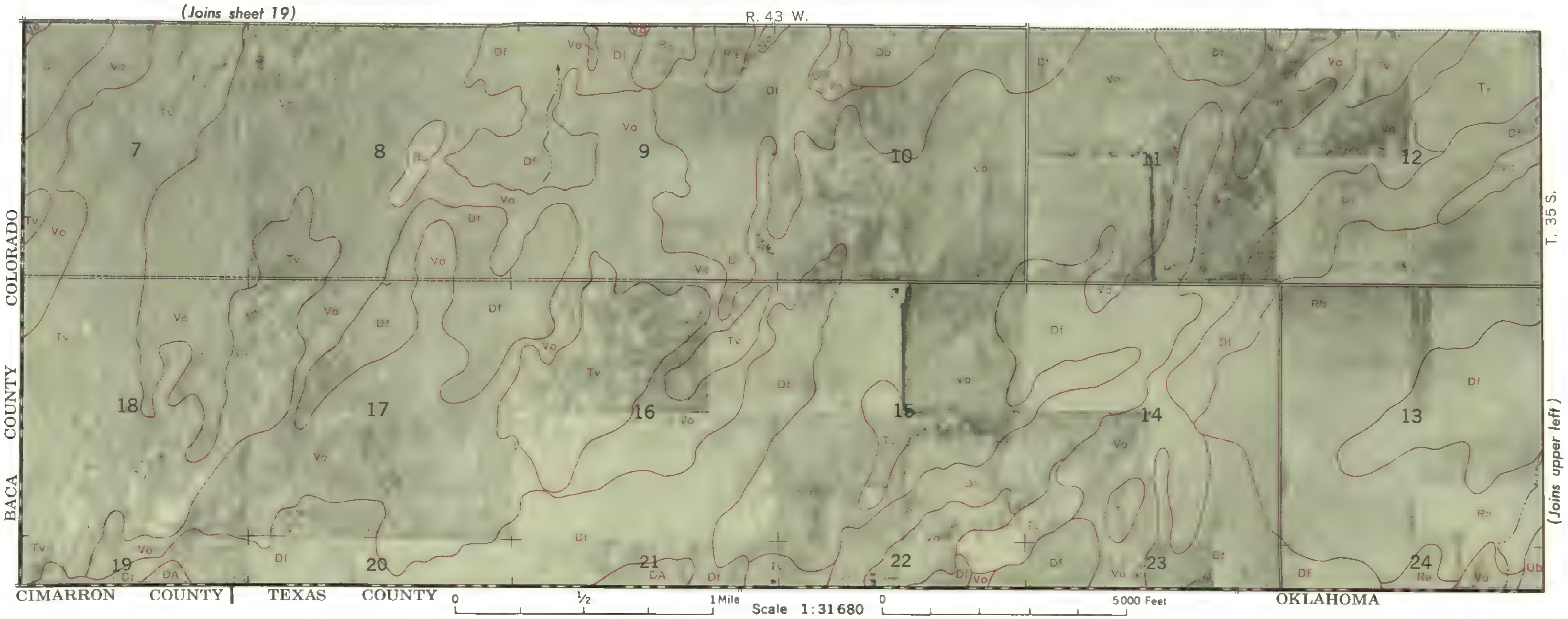
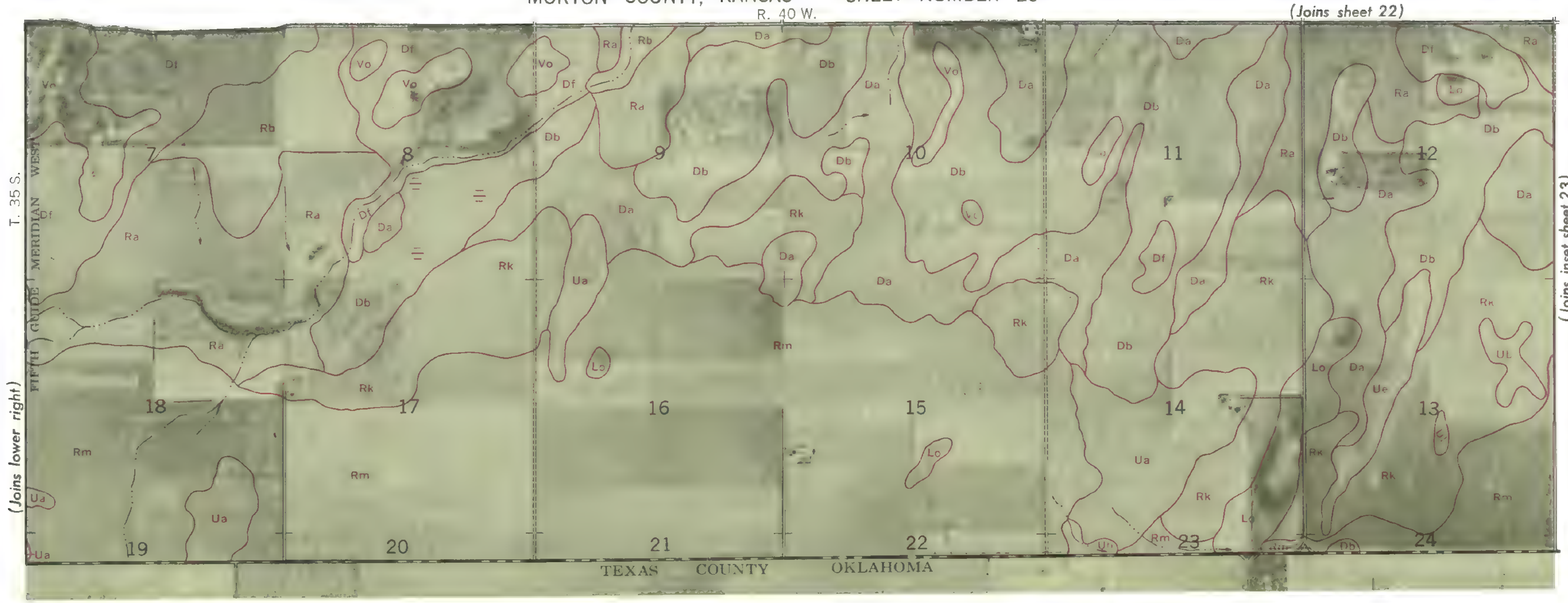
MORTON COUNTY, KANSAS — SHEET NUMBER 24

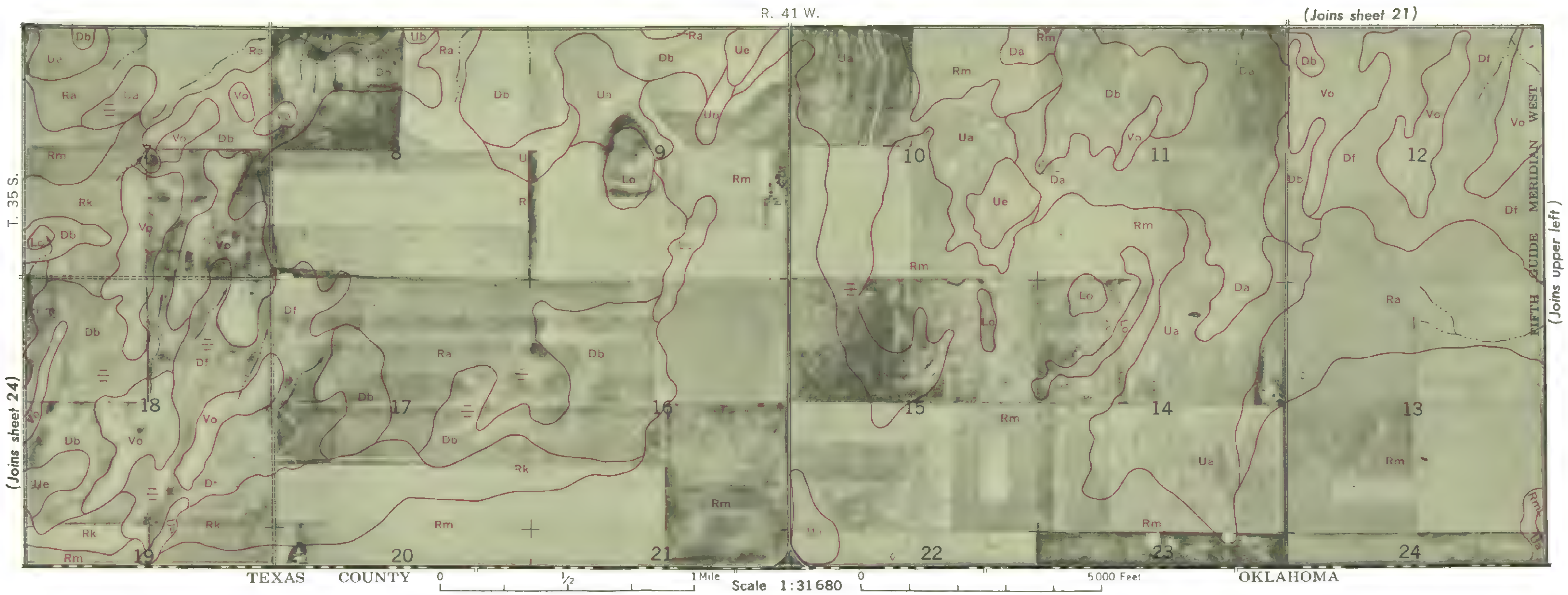




MORTON COUNTY, KANSAS — SHEET NUMBER 25

25





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4
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R. 40 W.
STANTON COUNTY
T. 31 S.
(Joins sheet 3)
(Joins sheet 9)
(Joins sheet 8)
CIMARRON MERIDIAN WEST
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1 Mile
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MORTON COUNTY, KANSAS — SHEET NUMBER 5

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MORTON COUNTY, KANSAS — SHEET NUMBER 6

MORTON COUNTY, KANSAS — SHEET NUMBER 7

0 ½ 1 Mile Scale 1:31680 0 5000 Feet

(Joins sheet 12)

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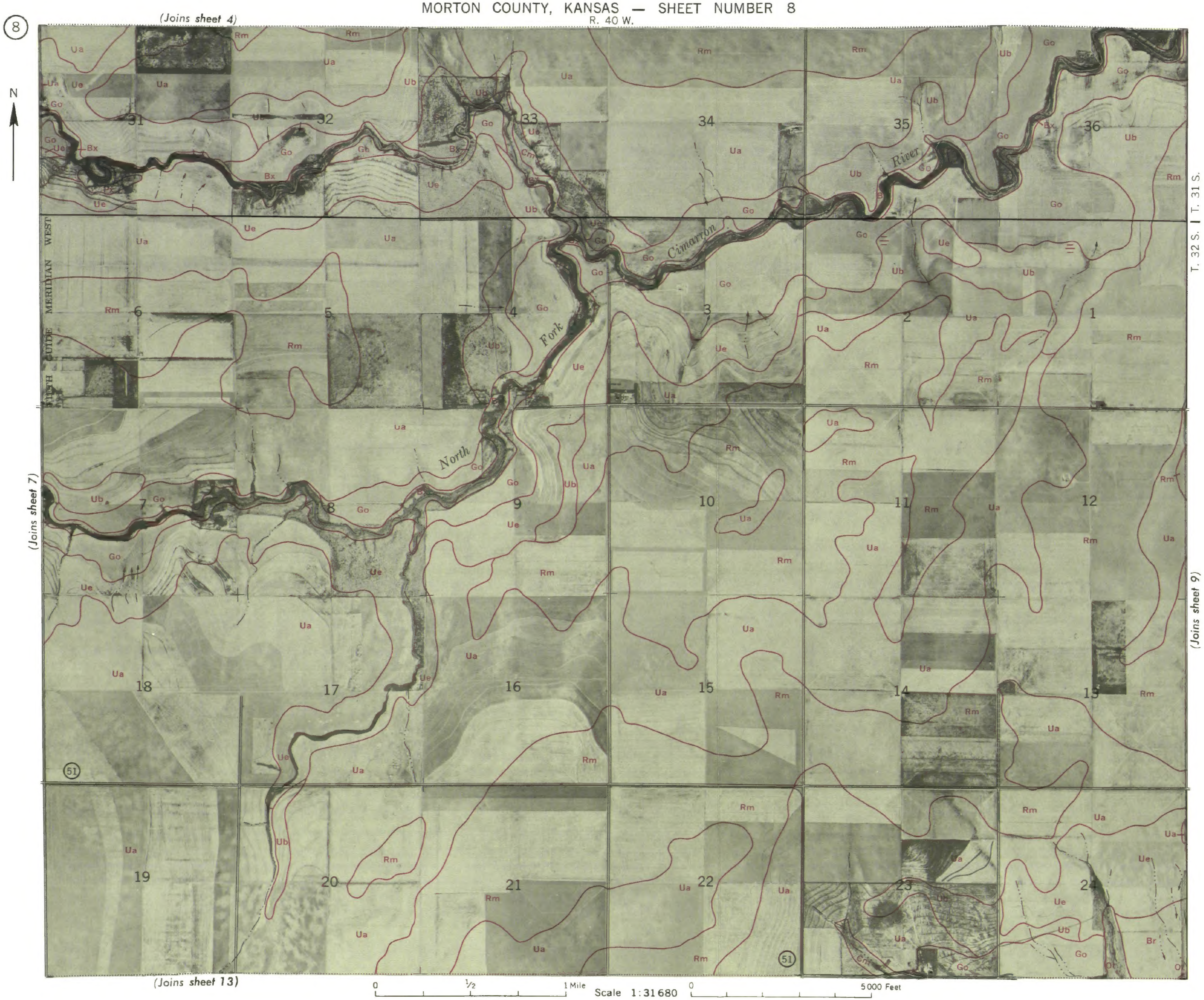
MORTON COUNTY, KANSAS — SHEET NUMBER 8



Scale 1:31680

0 ½ 1 Mile

0 5000 Feet

MORTON COUNTY, KANSAS — SHEET NUMBER 9

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